7 The Proposal

Preparing and submitting a research proposal is, simply stated, the most important aspect of building an externally funded academic research program. It's one of the most important activities associated with holding an academic position in a research-oriented college or university, and achieving success in an academic career is very much tied to the proposal preparation and submission process. This single activity will dominate your academic career, and for as long as you remain active in your profession. That is, your need to organize, prepare, write, and submit research proposals will never end. You will be involved in this process until you leave your academic position, either through your retirement, or to take another job. For this reason, you need to learn the basics of preparing a quality proposal that will give your ideas the best chance for obtaining financial support. You will learn that proposal writing is a skill that can be learned, and that, as you gain experience, the time and effort required to prepare a quality proposal will decline.

In this chapter we'll discuss the proposal and examine not only what it should contain, but also how to present the material in an effective style. Your ideas need to be clearly stated, but in a brief and informative manner. You don't want reviewers to have to struggle to find out what you are trying to present, or to learn what is new or novel about your ideas or your approach to the research problem you are addressing. You want the main ideas to be readily apparent, and to basically "jump" off the page to the reviewer. You want to make the reviewer's job as easy as possible. For this reason, many experienced proposal writers will use techniques to make critical statements impossible to miss. For example, many authors will place short, but critical, statements in bold type. We'll discuss these, and other, techniques as we go through the basic structure and presentation of the proposal.

The proposal is the main official mechanism for you to directly, and legally, compete for research funds, no matter the source of the funding. Proposals submitted to US government and private funding agencies will have essentially the same basic content, although the proposal format and certain items and required declarations and statements may differ slightly. A research proposal is, by definition, a legal document in which you make an offer to perform a defined research effort in exchange for financial support. The agreement is actually made, from a legal perspective, between your home institution and the funding agency, and your home institution research administration will provide the legal signature required for the proposal submission to be officially received and entered into the evaluation procedure. The research office, generally called the Office of Sponsored Research, or some other equivalent title, will actually submit the proposal to the sponsoring organization, and once you submit the proposal to your institution's research office, you are not directly involved in the process, although you will be informed of the proposal status. Since the proposal must be reviewed and approved by your home institution, you need to be aware of deadlines, and make sure you submit your proposal through your home institution's approval process in a timely manner to ensure that they have adequate opportunity to review your proposal and perform the approval process and submit the proposal in time for it to be received by the funding agency, consistent with their submission deadlines. The necessary lead time for your home research administration's review and authorization will vary from institution to institution, but will generally be on the order of two to five days, although more time may be required during periods when they are experiencing heavy proposal submission volume. This often occurs as the due date for popular proposal submission windows approach. The guidelines for the exact time for submission will be posted on your home institution's research administration website, and the information is readily available from them. Your research administration's review is not generally a technical review, but a review to check your budget, including items such as correct labor categories and rates, cost-sharing commitments, permitted travel obligations, indirect charges, and to make sure your budget is

consistent with the agency guidelines. They will also check to make sure any required declarations and statements are included.

Submission of the proposal to the funding agency will follow formal procedures, which are defined by agreement between the funding agency representative and your institution's research office. The requirements of the funding agency will be indicated and listed in the Call for Proposals, or other research opportunity announcement, and all proposals that are submitted by all proposers must adhere to the stated format and include requested items, declarations, and statements. Failure to follow the stated format, or to neglect to include necessary declarations or statements, will result in the return of your proposal to you without review. That is, once the proposal is received by the funding agency by the stated due date, it will be quickly scanned for format and content, and if any items are deficient, the proposal will not be entered into the evaluation process or read. Therefore, you need to carefully read the proposal solicitation and make sure you follow all guidelines. Submission of a research proposal to a funding source is, as stated, a legal procedure that is governed by applicable state and federal regulations and agreements.

Research funding sources will announce their funding opportunity, and you will prepare and submit a proposal to them, following criteria described in their Call for Proposals or other research funding opportunity announcement. The funding opportunity, which is open to all qualified bidders (proposers), may be for a specific research topic with a defined submission date, or it may be recurring and open for proposal submissions at any time during the open period. Whatever the specifics of the funding opportunity, you will devote significant time and effort on proposal development. In fact, you'll find that you will, most likely, and particularly in your first few years, spend almost as much time on proposal development as you do on any other single activity. Your home institution, of course, recognizes the importance of this activity, and many colleges and universities offer mentoring in proposal preparation in order to help new faculty members learn and improve their proposal preparation skills, and to facilitate the process. You need to become an expert proposal writer as the difference between submitting a successful proposal and being declined will depend not only upon the

quality and contents of the research objectives and plans presented in the proposal, but also how well the proposal is prepared and written. It cannot be overemphasized that writing skills and proposal organization are extremely important!

You need to learn what to include in a proposal and how to effectively present the information in order to receive favorable reviews. There is much skill and art in developing a successful proposal. However, there are several fundamental principles associated with preparing a proposal that will enhance your success. We will discuss these principles in this chapter, as well as the content and elements of an effective and well-structured proposal. You will find that, as you advance in your career, and go through the proposal preparation and submission process, your skills will improve and that the time and effort required for you to prepare a strong and competitive proposal will decrease.

7.1 Some General Comments From an Experienced Proposal Reviewer

Before we investigate the proposal preparation process in more detail, I can offer some general comments from my personal experience while serving in numerous and diverse proposal evaluation capacities. As a mature proposal reviewer with over four decades of experience reviewing proposals for a wide range of government and private research sponsors, I can tell you that many proposals are very poorly written, even by mature and successful researchers, even though they may contain interesting information concerning a specific topic and may include novel approaches to complex problems. However, if these ideas, concepts, and approaches are not clearly defined and explained, the proposal reader will not gain a clear understanding of the proposed research. Although a poorly written proposal may not necessarily limit a well-known and established researcher from gaining funding, the same cannot be guaranteed for a new or relatively unknown researcher. In these cases, the proposal writers do themselves a disservice, and place the potential of funding success for their research at a significant disadvantage by the failure to effectively communicate their research

ideas and approaches. Poorly written proposals tend to receive low ratings, even if the ideas contained in the proposal have merit and warrant being funded. Conversely, well-written proposals that very clearly and effectively present the research problem and include a solid scientific approach to address the problem often receive high ratings, even if the significance of the research problem is not well established, or the problem is not considered of the highest priority to the research community or the funding agency.

The principles for a good proposal that I list and describe in this chapter are derived from many years of service as a US government program manager, as well as service as a proposal reviewer for a wide variety of US government, foreign government, state government, private industry, foundations, and other research-funding agencies. I have also served as Chair of numerous proposal review panels for various government and private funding agencies and organizations, and have worked in management positions for US government funding agencies where I directed program managers and had management responsibility for their proposal review and evaluation activities. Along with my own experience both as a reviewer and also as a program manager directly involved with the proposal preparation and evaluation process, I have also observed how my proposal reviewer colleagues, from both government agencies and private institutions, perform their reviews and what sort of comments they tend to offer on proposals while serving on proposal review panels. I have personally reviewed a large number, probably approaching or exceeding 1000 research proposals, and sometimes with little time allocated to the review. For example, while serving as a program manager, I once was required to review and evaluate about 60–70 SBIR Phase I proposals for a US Department of Defense Agency over a time period of three to four days that extended over a weekend. I took the proposals home with me and spent the two-day weekend on my living room couch doing essentially nothing else but reading and evaluating proposals. Needless to say, under these conditions, only a limited amount of time can be devoted to each proposal in order to meet the schedule. Brief, well-written proposals have a much greater chance for receiving good evaluations, while lengthy and poorly written proposals

stand a high probability of receiving low evaluations. This particular review activity is probably a little extreme, but it demonstrates the pressure that can be placed upon reviewers. However, the need to evaluate a significant number of proposals in a limited time period is common for funding agency program managers and proposal reviewers. As a researcher, you want to make the job of the reviewer as easy as possible, and this can be best accomplished by learning to present your ideas in a clear and concise manner.

7.2 Who are Proposal Reviewers and How Does the Proposal Review Process Function?

Since the proposal review and evaluation process is so critical, you're probably wondering who will actually perform the function. You also may be wondering if you will have any ability to select or suggest people that you would like to serve as reviewers on your proposal. The answers to these questions, particularly the second, can be complicated, but in general, the answer to the second question is "no," you will not be able to select the reviewers for your proposal. Also, you will not know the identity of the reviewers. The NSF does permit you to identify people that you feel are qualified to review your proposal, as well as provide names of people that you specifically do not wish to serve as reviewers for your proposal. However, in my experience, the list of potential reviewers is seldom used, unless they are already in the qualified reviewer database. The list of people you are not comfortable with to serve as a reviewer for your proposal will not be selected. Mission agencies such as the DOD, DOE, NASA, etc., generally do not ask for a list of potential reviewers since they already have their own mechanisms and procedures for identifying qualified reviewers.

Essentially all grant funding agencies make use of a peer-review process where the identity of the proposal reviewers is blind to the author of the proposal. However, you can be assured that they will all be competent and technically proficient and qualified to perform the review. So, who are the reviewers and how are they selected? Proposal reviewers are your professional colleagues, and they are derived from a variety of

organizations, which could be other academic institutions, government agencies and laboratories, industrial organizations, and research institutes. Although you will not know their identity, their evaluation of your proposal and their comments will generally be provided to you. Also, you may request a debriefing on your proposal from the program manager or program director after the review and evaluation process is completed, and the program manager or program director will generally provide you with additional information regarding the review, sometimes indicating issues that were brought up during the panel deliberations.

The proposal reviewers will be selected by the program manager or program director based upon their expertise in the subject of the proposals that they are asked to review. Although all of the reviewers will be familiar with the technical area of the subject of your research proposal, some of them may lack in-depth knowledge of your specific proposal subject, and they may have only a limited knowledge of the scientific or technical details of your particular research topic or approach. Conversely, some of the reviewers will be experts in your subject and will have a deep understanding of your research topic. The program manager will generally recognize the range of expertise of the reviewers and will honor the limitations associated with certain reviewers. They will weigh the comments from the various reviewers in a balanced and appropriate manner.

If a panel is evaluating your proposal, the program manager or program director will generally assign your proposal to the reviewers with the most expertise in your specific topic, and will ask one of the most knowledgeable reviewers to lead the evaluation procedure. However, since you can expect that at least some of the reviewers that will be assigned to evaluate your proposal may have only limited knowledge of your subject, you need to learn to write your proposal for readers who are technically proficient, but not necessarily knowledgeable of the intimate details of your topic. You also need to include sufficient in-depth details for readers that have significant expertise in your subject. There is an art to writing a proposal with enough background information for general readers, while also including sufficient in-depth material to

demonstrate what is new or novel about your ideas and approach to the research problem you are addressing. The latter is very important since you are attempting to convince them that your ideas are worth the financial investment that you are requesting. Also, it is now common for funding agencies to limit the number of pages of technical information that can be included in a proposal, and this page restriction mandates that an appropriate balance of background and new material be presented in an effective manner. This is, in fact, one of the most difficult aspects of writing and preparing an effective and successful proposal. You will find that your writing skills improve as the number of proposals you prepare increases.

7.2.1 The NSF Proposal Review Panel Procedure

Before discussing the proposal review process, it's helpful to gain an understanding of the people that will organize the review of your proposal. At the NSF these people are called program directors. These program directors consist of a mix of permanent US government employees and temporary employees serving on leave from their home institutions. The temporary employees are generally academic faculty members serving in the program director role at the NSF under the US government Intergovernmental Personnel Act (IPA), which permits the government to hire personnel from non-government institutions and organizations on a time-limited and temporary basis. The IPA employees can serve as a program director at NSF for a limited period of time, for one year at a time, and extending up to four continuous years. While serving at the NSF under an IPA agreement they remain employees of their home institutions and, in fact, continue to receive their salary and benefits from their home institution. The NSF provides the institutions with the IPA employee's salary and benefits, and at the same rate as their normal salary, etc. There is no increase or decrease in the salary, and the NSF will modify the agreement to account for salary increases, etc. Some IPA program directors serve for an additional term, and the IPA program as used by the NSF, permits an IPA employee to serve at

the NSF for up to six years of the previous 10-year period. For example, a faculty member serving as a program director under an IPA agreement could serve a three-year period as program director, and then return for an additional three-year period as a division director. Other possibilities also exist.

The NSF primarily uses a panel review process to evaluate proposals for both their open window opportunities, as well as for directed solicitations offered under a Dear Colleague Letter. Once the proposals are submitted, generally through the NSF FastLane or Grants.gov websites, the proposals are scanned by the system to make sure they adhere to the proposal submission guidelines. That is, the system will automatically check to make sure certain information is contained, and that the proposal length does not exceed the maximum permitted number of pages. If the proposal does not meet the guidelines, it will be returned to the submitter without review and will not be further processed. The proposals that meet the guidelines are divided up by subject area indicated in the proposal, and then distributed to the program directors. The program directors will scan the proposals for content and to make sure they address the scientific, technical, or educational research area appropriate for the program director's area of responsibility. If the program director feels that a certain proposal is not appropriate for his or her panel, he or she may negotiate with another program director in another area, and the proposal may be transferred to a different area, or possibly, in rare circumstances, a different division or directorate.

Each proposal review panel will consist of a number of members, ranging from 12 to 15, although the number will vary from panel to panel, depending upon the subject area. However, panels that exceed 20 members are rare and discouraged, as they become too large to effectively manage. The program directors have the responsibility to recruit the scientific and technical experts to serve on the proposal review panels and the choice of who will participate on the panel is the program director's decision. In order to assist and facilitate this process, the NSF maintains a database of qualified reviewers, listed according to professional area and topic. The program directors make extensive use of this database to identify reviewers appropriate for their specific panel.

They may also recruit people who they know either personally or professionally to be experts in the scientific or technical subject of the proposal review panel.

Once the members of the review panel have been identified and successfully recruited, the program director will assign each proposal to a number of reviewers, generally ranging from four to six, and sometimes more. They will be contacted by email, and provided with information regarding the panel area, panel ID, and password information to log onto the NSF FastLane system. Once in FastLane, they have access to information regarding the panel, including travel and logistics details, proposal assignments, and the actual proposals that will be reviewed by the panel. Their specific assignments will also be indicated, and the reviewers will download the proposals, read and evaluate them, and enter both their summary evaluation and specific comments into the FastLane website. The summary evaluation consists of a grade, such as E for excellent, VG for very good, G for good, F for fair, and P for poor. All proposal reviews are to be completed before the time the panel meets, generally at or near the NSF office in northern Virginia, near Washington, DC. During the panel review, the grades and comments entered into the system during the preliminary evaluation process serve as the starting point for the discussions, but the panel will determine the final evaluations, and the initial grades may change during the panel procedure when the final proposal evaluation and grade are determined.

Program directors at the NSF do not generally personally evaluate proposals, and most do not actually personally read proposals, with the exception of the executive summary, along with a possible scan of the proposal to ensure they understand the topic. This is important since they are responsible for assigning the experts who will perform the detailed review, and they need to make sure they assign the proposal to reviewers with expertise in the subject. The primary function of the program director is to organize and manage the proposal review, to make sure the proposals are fairly evaluated by reviewers with expertise in the subject area of the proposal, and ensure a fair evaluation process. The program directors lead the panel in determining the final rank ordering of the proposals in any given competition.

The vast majority of proposals submitted to the NSF are evaluated by proposal review panels, where the reviewers will evaluate the proposals, discuss each proposal, and rank them, generally into one of three categories, consisting of: (1) Fund; (2) Fund, if possible; and (3) Do not fund. Often, after further discussions, this list will be reduced to two categories of (1) Fund and (2) Do not fund. The program director will have overall management responsibility for the panel, but will delegate a participant of the panel who is expert in the research area of the proposal to lead the discussion and evaluation of each proposal. Not all review panel members will read all proposals being evaluated by the panel. Each review panel will normally consist of about 12 to 15 reviewers, and each will possess either specific and detailed knowledge of the panel subject or, at least, a general knowledge of the research area. Each proposal will be assigned to a subset of the panel, generally consisting of about four to six members, and sometimes more. One member will be identified as the lead reviewer, and one member will be listed as the scribe. The lead reviewer will assume responsibility for leading the panel discussions on that particular proposal, and the scribe will record significant comments or issues that arise during the panel discussions. The scribe may or may not personally read and evaluate the proposal. However, each proposal is guaranteed to receive at least three in-depth technical reviews, and most will receive four or five. Each member of the panel will serve as lead, scribe, and reviewer on several proposals, with the exact number dependent upon how many proposals are to be evaluated in the panel. The program director will attempt to distribute the duties equally so that all panel members have a balanced work load.

During the review and evaluation procedure, the lead reviewer will normally manage the discussions of the proposal, and each member assigned to review the proposal will contribute their comments, generally starting with the comments they entered into the system in the review they performed before the panel meeting. They will also indicate their overall grade for the proposal. Each proposal is assured of receiving detailed reviews from the panel participants assigned to the proposal. In the proposal discussions, the members of the panel will

determine a single final grade for the proposal, and provide comments concerning the proposed research. If the grade determined for the proposal by the entire panel during the discussion doesn't agree with the individual reviewers' grades, they will often change their grades to be consistent with the overall panel grade. However, the individual reviewer grades will still generally vary and will not necessarily be the same as the overall panel grade. The scribe will produce a written summary of the proposal review, based upon the comments made during the evaluation procedure. The final summary is entered into the FastLane system, and is approved by all members of the panel, in order to assure that the scribe has accurately captured the panel evaluation. Panel members not specifically assigned the proposal may also offer their comments, and many do so if the proposal addresses a subject with which they are familiar. However, their comments may not be directly recorded or entered into the written summary, unless they enter themselves into the system as a reviewer, which they are permitted to do. At the end of the panel all panel members must concur with the final evaluations and grades entered into the FastLane system, and the system will not permit the panel review to be concluded until all members of the panel have done so.

During the panel review and evaluation procedure, the program director will normally group the proposals into those that have received all excellent or very good grades in the pre-panel reviews, those that have received all fair or poor grades, and the proposals that have received mixed grades. Those that have received all fair or poor grades may not receive detailed discussion, and may be quickly moved into the "Do not fund" category. Likewise, those that have received all excellent or very good grades may receive only brief initial discussion, and will be set aside for further discussion after the other proposals have been discussed. Most of the panel discussion time will be devoted to proposals where there is not a strong consensus concerning into which category the proposal should be placed. The program director will ensure that each proposal receives a fair and equitable evaluation, and there may be more than one round of discussions regarding certain proposals, particularly if controversy occurs. The final product of the panel will be a list of a small

number (generally no more than one to four) of proposals that the panel recommends for funding, and a list of the remaining proposals that the panel recommends to be declined. After the panel concludes its duties and departs, the program director will make the final determination of the list of proposals that he or she will recommend to be funded, primarily based upon the final panel rankings of the proposals, and will submit the recommendation to the NSF division director for approval. The program director will generally select a particular proposal to be funded from the list of proposals that have received the highest ratings. However, they may not necessarily select the proposal that received the highest rating due to considerations of subject area, emerging technologies, and other factors that the program director feels warrant consideration. The division director will give the final approval for funding, based upon their review of the ranked proposals and the division budget. The division director has access to all information and reviews entered into the FastLane system and has responsibility for concurring with the program director's recommendations.

Some highly ranked proposals may not be selected for funding, due to lack of sufficient available funds. These proposals would, of course, be declined. However, it is also possible that a highly ranked proposal not initially selected for funding could be held by the program director for a period of time, with the potential that the proposal could be selected for funding if additional funds become available later in the fiscal year. In these cases, the proposal writer will generally not be informed of any decision regarding the acceptance or declination of their proposal until a decision is actually made. This process and lack of communication can make the proposal writer very nervous regarding the status of their proposal. However, it sometimes is true that no news is good news, and patience on the part of the proposal writer is warranted. The results of the panel review are generally quickly disseminated, and the principal investigators and their institutions are promptly notified soon after the final decisions have been made. If you do not receive notification of the final status of your proposal in a timely manner, your proposal may be in the hold category. This situation is, in fact, common since additional funds generally become available at the end of each fiscal year,

a situation that occurs since funds appropriated by Congress need to be entirely spent and the budget zeroed at the end of each fiscal year. If funds are not spent by the end of the fiscal year by a US government agency, they are returned to the Department of Treasury and their budget could potentially be reduced by that amount in the following year. This, of course, provides high motivation to US government agencies to completely spend their budgeted funds each fiscal year.

At the NSF, if the appropriated and allocated budget to each directorate and division has not been entirely spent during the fiscal year, some funds may remain towards the end of the fiscal year, and this generates the opportunity for some additional highly rated proposals to be selected for funding. The NSF manages this process on the directorate and division level, and at the end of the fiscal year, the directorates will normally perform what they call a "sweep" of unspent funds in each division's budget. These are funds that have not yet been committed to fund proposals. Once the sweep is concluded, the directorates will often send out a message to each division director announcing that additional funds are available for proposal support. This provides the opportunity for additional highly rated proposals to be funded. Many program directors who have held one or two proposals that they feel should be funded will submit these proposals to the division director for consideration of funding. The division director will generally make use of this procedure to fund areas that he or she feels important and deserving of additional support.

Proposal evaluation panels are fundamental to the review and evaluation procedure, and you should become involved in the proposal review process as soon as possible. As your career progresses and you publish and present your work in professional forums, at some point you will likely be asked to serve as a research proposal evaluator and reviewer, either for a single proposal, or on a research proposal evaluation panel. The NSF, in particular, is always looking to expand their base of proposal reviewers. You should accept as many requests as possible to serve on proposal evaluation panels. The experience is very interesting and enjoyable, and is invaluable for learning the content and structure of both well-written and poorly written proposals. You will also learn how

research proposals are evaluated, and this will help you to develop your proposal writing skills. Also, service on a research proposal evaluation panel offers an excellent opportunity to make personal contacts with both NSF program directors and your professional peers and colleagues. In order to volunteer as a proposal reviewer, you can contact an NSF Program Director and request to be added to their list of reviewers. They will likely respond favorably and ask that you complete a form that asks for your contact information, area of expertise, and your credentials. Once they receive this information, they'll consider your request, and then add you to the list of reviewers in the database. Once you serve on a panel, you'll likely be requested to serve on additional panels in the future.

7.2.2 Mission Agency Proposal Review Process and Panels

Program managers at other government agencies, such as the DOD, DOE, NASA, etc., consist primarily of permanent US government employees. The mission agencies also make use of IPA employees obtained from non-government organizations, such as academic institutions and industrial organizations, but in much smaller numbers than used at the NSF, and only for specific reasons. That is, they do not generally recruit outside people to serve in their institutions as program managers under IPA agreements unless there is a specific need or reason to do so. The program managers in certain mission agencies may be scientists or engineers on detail from other US government organizations. For example, many of the program managers serving at DARPA are employees of other DOD organizations, such as ONR, AFOSR, ARO, etc., and will return to their home organization once their detail period has expired. A primary purpose of the detail is to acquaint the program manager with DARPA programs, and attempt to bring enhanced alignment between the DARPA programs and their home organization plans and programs.

The program managers in the mission agencies operate in a similar, but slightly different, manner from program directors at the NSF. For example, the majority of program managers at most government

agencies, other than the NSF, are permanent, professional government employees and, as discussed in Chapter 6, are building and financially supporting a research program to achieve an overall goal, consistent with their office and agency mission. How they handle your proposal will vary, depending upon how it was received. If the proposal was submitted in response to a specific Call for Proposals on a defined subject, a panel of experts, generally selected by the program manager, will most likely evaluate the proposal. In this case, the panel evaluation will proceed in a manner analogous to that discussed above for NSF panels. However, the program manager may, or may not, actually read your proposal personally, depending upon their level of interest in the subject of your research. You want them to personally read your proposal so you need to communicate with them before submitting your proposal to determine their specific interest areas. The program manager will generally actively participate in the panel review and will often make specific comments regarding proposed approaches, recent developments, and other factors. Keep in mind that they are focused upon accomplishing an end goal, and they are looking for scientific and engineering contributions that will assist them in their overall objectives. The final selection of the proposals that are to be funded will be made by the program manager, and possibly their office or agency colleagues, based not only upon the review panel rankings, but also upon their overall and specific program goals. In some cases, they may select a lower-rated proposal to receive funding over a higher-rated proposal, where they based the final decision upon the technical subject, their desire to have research performed on a specific subject, and on how well they feel the proposed research coordinates with other research that will be performed on the project or development area.

7.3 How Experienced Reviewers Read Proposals

Professional program managers and program directors receive and read a large number of proposals. They also recruit a large number of experienced reviewers to assist them in evaluating the proposals they receive. Experienced proposal reviewers become very skilled at reading

a proposal and can quickly and effectively determine what is being proposed, and the significance of the approach and research topic being proposed. Most experienced reviewers will initially speed-read a proposal, skimming over certain information, while seeking the real "meat" of the proposal and attempting to identify exactly what topic is being addressed and what advance is being proposed. For this reason, you want to make sure your specific contribution and approach are very clearly and precisely stated. Once they have a good idea of what you are proposing they will also look for information relative to: (1) the fundamental research problem, including previous work done on the subject and the current state-of-the-art; (2) the approach to be pursued, including what is new or novel about the proposed approach; (3) supporting data and previous results; (4) the proposer's access to equipment, instrumentation, laboratory facilities, and other resources necessary to perform the research; and (5) the credentials of the principal investigator (PI). If any of these items are not included or adequately addressed, the omission will be considered a deficiency and the proposal rating will be downgraded. The proposed budget will also be examined, but generally only in a brief manner. Generally, reviewers will look to see if overall budget requirements are met, if the PI has included adequate funds for their time, student support, and if they have requested reasonable amounts for supplies, travel, etc. However, the budget details are generally left for the agency program manager to evaluate, and the proposal reviewers will make comments only if something looks inconsistent with overall program goals, or something that appears inappropriate is included. Experienced proposal reviewers will scan information generally considered as "boiler plate" information. That is, standard information regarding laboratory and computer facilities, the university support for research, and other generic information concerning the university or its desire to build their program. While this information may include some valuable factors, most program managers and reviewers will only scan the material, unless something catches their eye that they feel affects the proposed research or the ability of the PI to perform the research.

The reviewer will generally form an initial opinion and draft rating for the proposal from this initial reading and evaluation, and the other information included in the review will be left to a more-detailed final review after the initial opinion has been determined. The initial reading will direct the reviewer towards subjects and topics that require a more detailed reading in order to fully understand the proposed research. Information related to items identified in the initial scan or items that piqued the reviewer's interest will be the subject of the more detailed evaluation, particularly if the reviewer felt he or she was confused over a subject and thought that a critical detail was missed or not understood. The detailed review will focus in these areas. Once the reviewer feels that he or she understands the proposal, the review will be terminated, and this information will then be used to determine the final rating and summary comments. Many times the final rating is primarily based upon the initial reading, particularly for either very well-written proposals focused upon timely research topics, or for very poorly written proposals that present little new information or are not concerned with a research topic of interest. The latter issue is more common for proposals submitted to mission agencies, where the opportunity is directed to specific defined research topics, than for proposals submitted to the NSF, where proposals on a wide diversity of topics are generally considered acceptable for a given opportunity. However, even the NSF will reject proposals for lack of interest reasons when the proposal is submitted in response to a defined research topic and the proposal topic does not fit well within that topic.

For these reasons it is very important that the proposal be clearly and concisely written. Also, major items that are the focus of the proposal need to be clearly defined and simply and explicitly stated. Overall, and for a first read, the reviewer may spend only 10 or 15 minutes on your proposal, or they could spend an hour or more. Less time is required to review very well-written, and very poorly written, proposals. These two categories of proposals are generally easy to determine, and the evaluations will generally be quickest and easiest to perform. Proposals that do not clearly present the case for why the research is worth funding, or that confuse the reviewer, may take longer to review. Proposals that require

that the reviewer spend an hour or more to review and evaluate often will not be highly rated, although this will vary and there are certainly good reasons a reviewer will spend extra time reviewing a proposal, particularly if they feel it may contain a novel concept or approach. In this case the reviewer may spend extra time to make sure their evaluation is, in fact, correct. However, most reviewers will not have the time to spend an hour or more evaluating a proposal when they have a significant number of proposals to review. In these cases, the proposal author, by submitting a weakly written or disjointed proposal, is gambling that the reviewer will spend the extra time to evaluate the proposal, which may require the reviewer seeking out additional information from other sources. While many reviewers will take the time and spend the effort to do this, this is not guaranteed. They may simply give the proposal a poor rating. In my experience I've seen reviewers take both options, and I've witnessed many proposals receive poor ratings, even when the proposal actually included novel results or a novel approach, but the proposal was not well written. If the reviewer doesn't completely understand the ideas in the proposal, it's very easy for them to simply conclude that "the proposal contains nothing new." I've also witnessed proposals that contained very incremental approaches and less than impressive results receive excellent ratings, simply because the proposal was very well written.

7.4 Basic Principles for Preparing a Research Proposal

As mentioned above, there is much skill and art involved in preparing and writing a high-quality research proposal. You want to enhance your chance for having your proposal favorably received and reviewed, and this can best be accomplished by learning to present your ideas in an effective, concise, and professional manner. You want to present yourself as a competent and skilled researcher with novel and new ideas that will advance your field of research. However, just being competent with novel research ideas generally isn't sufficient for success in obtaining research grants. You also need to learn to effectively present your ideas through well-structured

proposal organization and presentation. We will discuss the elements of a well-constructed proposal in this chapter, but first we'll review some basic principles that will prepare you to organize and construct an effective research grant proposal.

7.4.1 Principle 1: Know Your Subject

Knowing your subject may seem to be an obvious principle. In fact, you were most likely recruited to your current academic position based upon your expertise and perceived ability to build an effective research program. You have probably devoted much time and effort to your research and feel yourself highly qualified. However, you are now competing for research grant funds on a national basis and your proposal will be evaluated in competition with other proposals submitted by both mature and new investigators. In addition to your obvious familiarity with your own work, you should be familiar with work presented in the major publications and major conferences in your field by other researchers. It's important to know the latest developments in your field and the identities of the major researchers in your field. Basically, you need to know your competition and what approaches are being pursued. Different researchers pursue different approaches, and there may be controversies regarding certain results or approaches that have been presented. If your subject contains some controversial elements or concepts, there may be panels at conferences or workshops devoted to the issue. If so, you should make every attempt to attend these meetings and participate in the discussions. You need to be aware of the scientific or technical issues and questions that have been raised, particularly if your research approach favors or follows one of the prevailing approaches. If your proposal topic is in a controversial subject, keep in mind that reviewers who favor an alternative approach may review your proposal, and this could result in your proposal receiving an unfavorable review. Therefore, you want to write your proposal in as non-controversial a manner as possible. However, demonstration of a thorough knowledge of the subject will always work to your advantage. For example, with a controversial topic, various alternative approaches or

theories should be discussed in the background, along with both positive and negative factors associated with the various approaches. You should then describe your proposed research, and position your approach in a manner to help elucidate further knowledge that will help clarify the subject. In this manner you can address the scientific and engineering basis of the research without the need to take one side or the other.

7.4.2 Principle 2: Not All Proposals are the Same – Learn to Write Your Proposal for the Funding Agency and Their Reviewers

Although the vast majority of proposals that are submitted, regardless of funding agency, will have essentially the same content and the same general format, there are distinct content differences that need to be recognized. We'll discuss these content differences later. However, an often overlooked, but very important, factor to recognize is who will, most likely, review and evaluate your proposal. That is, you should anticipate if your proposal will be reviewed by professional scientists and engineers employed in the funding agency, or by outside experts. You should seek to know if there is a directed theme to the Call for Proposals, or if the funding agency is simply looking for proposals that present the best science or engineering ideas. The former is common in mission agencies, whereas the latter is common for the NSF. You should then structure your proposal and present your information with regard to the anticipated reviewers so that they will be easily able to understand your ideas. There is a difference regarding how your proposal will be reviewed, depending upon the funding agency to which it is submitted, and you should write your proposal with the anticipated reviewers in mind.

For example, your academic colleagues will review virtually all proposals submitted to the NSF, with the possibility that a small number of reviewers will come from government agencies or private companies. Since academic peers will be the most likely reviewers for your NSF proposal, you should take extra care to make sure you adequately explain the background to your research and indicate the significance of your approach and your past results, if any. You can also anticipate that your

proposal, if submitted to the NSF, will be reviewed and evaluated by a panel of experts. You should assume that at least some of the reviewers will have only marginal or limited knowledge of your research topic. This situation is made quite likely by the very strict conflict-of-interest (COI) policies employed by NSF. Under these COI policies, anyone submitting a proposal to a specific Call for Proposals (called a Dear Colleague Letter by the NSF) is disqualified from serving as a proposal reviewer on any panels associated with that particular research opportunity. Since many experts will submit proposals to a given and specific research opportunity, many very knowledgeable experts are not able to serve as reviewers. You can almost be assured that the most knowledgeable experts on that particular subject will also have submitted proposals and will, therefore, not be among the reviewers. The NSF program directors will often address this situation by recruiting reviewers who are skilled in related, but not necessarily the same, areas of expertise. They will be familiar, in general, with the subject, but will not necessarily be experts familiar with details of the existing or proposed research. Also, the COI policies will not permit anyone from your home institution, anyone with whom you've served as a co-author on a publication at any time in the past four years, or anyone with whom you've served as a co-editor of a journal, compendium, or conference proceeding at any time in the past two years, to serve as a reviewer for your proposal. Therefore, it is likely that some of the panel reviewers assigned to your proposal will not have detailed knowledge of your topic, and you need to recognize this and prepare your proposal appropriately, and concisely and effectively explain your research, taking care to note why it is important, and what is new that you propose to add to the subject. You should clearly state, and indicate, new and novel results and ideas explicitly. Keep in mind that the NSF is primarily looking for the best research proposals addressing subjects in a relatively general area, and not necessarily research proposals that integrate ideas in a tightly synchronized manner from the various proposals being evaluated.

Proposals that are submitted to mission agencies, such as the DOD, DOE, NASA, etc., are processed in a slightly different manner, and scientists and engineers from agency laboratories, along with selected

academic experts, will likely review the proposals. However, the academic experts will be selected based upon their specific expertise in proposal subjects, and can be expected to have detailed knowledge on your topic. Often, your proposal will be reviewed by the most knowledgeable experts in a specified subject, and particularly if those experts are also funded by the agency to which the proposal has been submitted. Mission agency program managers have a tendency to ask scientists and engineers they are funding to serve as reviewers for other proposals they have received.

Mission agencies will use both expert panels and individual expert reviews for proposal evaluation purposes. For specific topic research announcements, you can anticipate that proposal evaluation panels will be employed. However, you can expect that essentially all the reviewers assigned to evaluate your proposal will have significant or intimate knowledge of your research topic, and how your research fits into the overall area described in the announcement. However, if you submit an unsolicited proposal in response to an open BAA, you can anticipate that three to five individual experts will be asked to review your proposal. The experts will be selected from internal agency offices and laboratories, and outside academic organizations, and all reviewers will generally have intimate knowledge of your research topic. The proposals are generally sent by email to the reviewers, who will perform the evaluation at their home institutions, and then input their ratings and summary on the agency proposal website. Proposals submitted to the mission agencies should include background information, but this information generally doesn't need to be presented in the same manner as for proposals submitted to the NSF. In the background section you should indicate the general status of the research topic, taking care to note the most important developments. You want to set the scene in order to describe the advance you are proposing. You also want to indicate to the reviewers that you have a good understanding of the state-of-the-art and the various approaches that have been presented. For proposals submitted to mission agencies, the overall goal of the background section is to convince the reviewers that you have a complete understanding of the

field, including work done by your colleagues and competitors. However, for proposals submitted to the NSF, the overall goal of the background section is not only to establish yourself as an expert, but also to educate the reviewer about the current state-of-the-art and recent developments.

7.4.3 Principle 3: Read the Call for Proposals!

This principle may seem obvious. Indeed, it is! However, in my proposal review experience, I've continually been amazed at how many proposal writers ignore vital information or proposal submission requirements clearly stated in the Call for Proposals, or other research opportunity announcement. Most research opportunity announcements will include restrictions on factors such as the following.

(1) **Performance Period**

The period of performance will be specified in the announcement, and will range from six months for SBIR Phase I proposals, to 10 years for large center NSF proposals. The typical performance period for a standard, single PI proposal will be three years. However, many funding opportunities will specify a one-year period of performance. Often the funding opportunities will permit follow-on proposals for additional funding. The follow-on opportunities are common for DOD funding agencies. For example, a typical DOD research grant will be for an initial three-year period of performance, with the possibility for additional research work supported through submission of a follow-on proposal for an additional three-year period. Proposals submitted to the NSF are typically funded for a three-year performance period. Generally, follow-on research is not directly possible, and any extension of the research will require a new proposal submission. The follow-on proposal can build upon the previous research results, but will need to clearly describe the work performed and accomplishments of the original research, as well as the research to be performed under the new grant. The new proposal should be submitted during an open window for proposal submissions, and will be evaluated and reviewed in competition with all other proposals received during the open period.

(2) **Budget Limits**

Most Call for Proposals or other research opportunity announcements will generally indicate the amount of funding that is available for the research opportunity, both for the overall program, and for individual proposals. It's very important to recognize these limits and to structure your research plan accordingly. If you fail to follow these guidelines, and make your budget either too small or too large, you will decrease your potential for successfully obtaining funding. An unrealistic budget submission will generally not prevent your proposal from being reviewed, and the budget is generally not a primary concern in the initial reading, unless the budget is completely unreasonable, or contains items not permitted under the guidelines. Indeed, the research to be pursued is the most important aspect of the proposal, and the reviewers' focus will be directed to this area. However, the budget will be considered in the evaluation, by both the reviewers and the program manager, and will be correlated with the proposed research effort. An unrealistic budget will be a negative factor in the evaluation. If the budget is too low, there will be questions regarding the scope of work and concerns if sufficient funds have been requested in order to permit the research to be successfully performed. Conversely, if the requested budget is too high for the funding available on the program, or for the research that is proposed, there will be questions concerning the breadth of the proposed research, the overall proposal focus, and questions regarding the ability to actually perform the proposed work with any realistic expectation for success.

If the proposed research is of high quality and the recommendation is to accept the proposal, the program manager may contact you and ask for a revised budget that is consistent with the available funding. In this case you will need to reduce the requested funding, and redefine the scope of the research and the specific research tasks to be pursued. When a budget needs to be reduced, quite often, and particularly for mission agencies, the program manager will contact you and inform you of the exact level of funding that will be provided. You will then need to revise your proposal accordingly. This is a common occurrence. For certain research opportunities, such as

the NSF CAREER awards, there is a defined and specific budget amount that will be provided indicated in the announcement, and your proposal needs to be written for exactly this amount. The NSF will not proceed with the award of CAREER grants until the proposal budget satisfies the defined support level.

(3) **Number of Pages and Font Size**

Many research opportunities will indicate a limit to the number of pages that the proposal should contain. This limitation generally applies to the research narrative where the research that is to be pursued, along with the research plan and tasks, are described. For example, proposals submitted to the NSF are limited to 15 pages of research narrative. Similar page limits are generally associated with proposals submitted to other agencies and funding sources. The research narrative page limit does not include references, authors' biographies, budget, or any required statement and declarations, etc. The NSF 15-page research narrative limit must be respected, and the NSF FastLane system will not accept research narratives in excess of this limit. Often researchers wish to include more information than can be accommodated in 15 pages, and they will attempt to employ tactics such as the use of small font sizes, reducing page margins, etc. These tactics should not be employed. In particular, small font size makes it difficult for reviewers, and this could result in a reduced evaluation. Minimum font size is usually indicated in the announcement, and font size less than 10 point should never be used. Also, minimum page margins are indicated in the announcement and should be respected. You need to learn to prepare your proposal for the defined logistics, and the best approach is to concentrate on learning to present your ideas in a clear and effective manner, while respecting the proposal restrictions. Failure to do so could result in your proposal being returned to you without review.

(4) **Address Every Scientific, Technical, or Programmatic Topic that is Described in the RFP**

This is probably one of the most, if not the most, important principle for you to understand, and one which is often ignored. In fact, I've read many proposals where the Request for Proposal (RFP) clearly requested information on a range of topics that were described and

outlined, sometimes in significant detail, only to have the author of the proposal pick-and-choose the items they wished to address. They would direct their proposal to certain topics on the list, generally the ones with which they were most familiar, and the ones to which their particular research was applicable, while ignoring the other topics. Although this approach is attractive for a single investigator, including only a portion of what is requested is a major mistake! When the RFP requests a list of topics to be addressed, the program managers have determined that they wish to fund a comprehensive research program to advance a given topic. They have already performed a strategic analysis of the topic and determined the advances that are necessary to more fully pursue the necessary research to achieve their overall objective. For example, in the program description they will often include a brief history and overview of the topic, including possible approaches, which have been determined from previous research. Often, in order to successfully compete for these funding opportunities, it will be necessary to identify and recruit researchers with whom you can collaborate, with each of the researchers focused upon a particular topic discussed in the RFP.

The program managers understand that it is unlikely that a single investigator will have the expertise to address all topics that are defined, and they expect that multiple investigators from various organizations will be included on the winning proposal. When the proposals are evaluated, the program managers will ask the reviewers to address all topics in the RFP, sometimes providing score sheets to be used, with each specific topic listed for evaluation and rating. If a proposal does not include that particular topic, it will be poorly rated. The main point is to read the RFP carefully, and make sure every requested topic is addressed. If it is not possible to address every topic, you should contact the program manager listed as the point-of-contact (POC), and discuss your research and possible participation in the research. The program manager may suggest that you participate with another group, or they may be willing to accept a limited proposal if your research is particularly attractive for one specific part of the program.

7.4.4 Principle 4: Make Sure Your Proposal is Not Summarily Rejected

One of the most frustrating and discouraging things that can happen is for you to identify a very interesting problem, develop a promising and novel research plan, and then spend many hours of focused effort writing an excellent proposal, and one that may also include results documented with data from previous research, and then you're ready to submit your proposal. You get your proposal submitted and approved through your institution's internal process, and you get the proposal submitted to the funding agency. Then you find that the agency won't accept your proposal, or that your proposal is immediately returned without review. How does this happen? And can you still get your proposal accepted for review by the agency. The answer to the second question is unfortunately "no," you're out of luck. This frustrating situation, although not common, does occur. So, what happened, and how can you avoid this situation?

The first thing you need to recognize and respect is the funding agency due date. Grant funding opportunities advertised on specialized RFPs, Calls for Proposals, Dear Colleague Letters, or other grant funding announcements, when the opportunity is directed towards a particular subject or topic, will almost always indicate a due date by which all proposals must be received at the funding agency. As a practical matter, there is essentially no or very limited flexibility on the due date and proposals received after the due date will not generally be accepted. This requirement is a hard date and is rarely extended, no matter the situation. In the days before electronic submissions, many proposal submitters would actually make trips to the funding agency to personally deliver their proposals and to make certain that the proposal was received by the funding agency before the due date.

As a personal experience, I recall one proposal I wrote many years ago and submitted to a grant funding agency. In order to have the proposal delivered to the funding agency by their due date I sent it through an express mail delivery organization, which guaranteed timely delivery. The proposal was scheduled to be delivered the day before the due date.

As you can probably guess, my proposal package was misplaced, and held up in delivery for a couple of days, which resulted in the proposal failing to be submitted by the funding agency deadline. The proposal was returned to me unread. When I checked with the express mail delivery service, they tracked the package, and then apologized for the late delivery. They then honored their guarantee by returning my mailing fee! Of course, this action left me out of the proposal competition. The electronic submission procedures now in place at most grant funding agencies prevent this sort of problem, but the due dates still must be honored and respected. As a principle, it is never a good idea to wait until the last minute to submit your proposal. There are many instances where computers crash, or where email, web-based systems, or networks may experience problems and be temporarily unavailable. Any of these problems could cause you to be delayed in submitting your proposal, particularly if you are planning to get everything submitted just a short time before the deadline. It is unlikely that any of these events would be accepted as excuses and result in the funding agency accepting your proposal beyond the due date. You don't want these types of failures to delay your proposal submission. Plan to have your proposal submitted with at least a day or two of lead time.

One exception to the necessity to meet the hard deadline for proposal submission is the occurrence of a natural disaster, where a certain degree of flexibility is permitted. The NSF, in particular, but other funding agencies as well, will permit delays in meeting the proposal submission due date. In the case of a natural disaster, proposers to the NSF need to contact the cognizant program director in the division or office to which they intend to submit their proposal, and request authorization to submit a "late proposal." If an adequate and convincing argument is presented, the NSF may permit an extension of the deadline by five business days. However, the extension must be approved in advance, and simply missing the published deadline by five days is not acceptable.

Other reasons that your proposal could fail to be accepted and returned to you without review relate to the failure to include mandatory statements, declarations, or other required information. Many

grant funding opportunities will often request certain information be included in the proposal that is related to special topics not necessarily related to the research topic, or special requirements that are defined in the Call for Proposals, Dear Colleague Letters, or other research opportunity announcements. These special requirements need to be recognized and addressed. For example, the NSF requires that all research proposals submitted to it include a Data Management Plan (DMP). This is a supplementary document of no more than two pages labeled "Data Management Plan". This supplementary document should describe how the proposal will conform to NSF policy on the dissemination and sharing of research results. The DMP needs to be included, even if you do not anticipate that data will be generated in the course of performing the research. In this case, you would state in the DMP that you do not anticipate that your research will generate data that require management and/or sharing. Proposals that do not include a DMP will not be accepted and will not be able to be submitted on the NSF FastLane.

Another special requirement applies to proposals that contain post-doctoral researchers and are to be submitted to the NSF. These proposals must include a Mentoring Plan, which describes how a post-doctoral researcher engaged in the research will be mentored and advised, including a description of the mentoring activities that will be provided to them. Also, proposals that request funding for the support of post-doctoral researchers must include a Mentoring Plan as a supplementary document to the proposal. These requirements were mandated by Congress in Section 7008 of the America Competes Act.

Each of these items can be briefly described, usually in two pages or less. However, failure to include either the DMP or the Mentoring Plan will result in FastLane not accepting your proposal. That is, the FastLane system will not accept the proposal, and the proposal will not be distributed or even seen by a program director. Other funding agencies and sources may also include similar specialized topics that need to be addressed. For this reason, you need to learn to carefully read the research opportunity announcement and make note of any specialized

requirement. In the proposal these topics need to be addressed in a very concise and effective manner.

7.5 The Basic Proposal

In this section we address the basic proposal structure and content, and describe how best to present the required information. I'll describe the main elements of a proposal from a generic perspective, while a proposal submitted to a specific funding agency may not require all the elements. However, all the elements discussed in this section will be required in proposals, depending upon the funding agency. For proposals submitted through the NSF FastLane or the US government Grants.gov websites, the various proposal elements are entered as separate documents, and it is very important to closely follow the submission format since the website will not accept documents that do not meet the requirements. More detailed information addressing the requirements for a specific agency is generally available on the agency website. For example, detailed information concerning proposal content required for proposals submitted to the NSF can be found in the NSF Grant Proposal Guide (http://www.nsf.gov/pubs/policydocs/pappguide/nsf15001/gpg_print.pdf).

There are differences in proposal organization and structure, depending upon the funding agency requirements and guidelines, but in general all research grant proposals will address and present information identifying and defining the problem that is being addressed, what new research is being proposed in order to contribute to advancing the topic and solving the problem, along with a plan for implementing and performing the research. Requested budget details, along with a description of who will participate in the research, are also presented, along with a description of the equipment and facilities available to be utilized in the research. This information is common to all proposals. Additional information addressing specific requirements and details requested by particular funding agencies and sources may also be required, but this information and the relative details will vary from funding agency to agency. Often this information, such as letters of support and specific declarations and statements, will be included as an attachment to the proposal.

So what's included in a basic proposal? A basic research grant proposal, common to essentially all funding agencies, will include and consist of the following elements, in roughly the order presented below.

- A title page or cover page
- An abstract, executive summary, or project summary
- A table of contents
- The project narrative or project description
  - An introduction
  - A problem background section
  - Results from previous research
  - The research to be performed
- A statement of work
- References cited
- Personnel biographies
- The requested budget, including a budget justification
- A description of the laboratories, equipment, and facilities available to perform the research
- Special information and supplementary documentation

Each of these elements will now be briefly described.

7.5.1 The Title or Cover Page

Most funding agencies have specific requirements for the title or cover page, so you should make sure you follow them. Often, agencies will have standard cover sheet forms that will be completed by filling in the necessary information. For example, the NSF Fastlane system will request information that will automatically be transferred to the cover sheet, and this sheet will appear with your completed proposal. The title or cover page includes the title selected to briefly describe the research that is addressed in the proposal, along with the names of the principal investigator(s) who will perform and/or direct the research, the institution affiliation of the PI, including the department and university, the identification of the agency and address to which the proposal is being submitted, the performance period and dates of the research, the

amount of funding being requested, and the signatures of the PI and the university official authorized to sign for the university. The date of the proposal submission is also often listed. The title should be brief, but accurately represent the research that is being proposed and should include keywords that relate to the research. The keywords are useful for database classification and searches. It is best to avoid overly lengthy titles. If more than one PI is involved, all names should be listed on the title page. However, only list those identified as principal investigators, and not others who will participate, but are not identified as a PI. The other contributors to the research will be included and identified in the personnel descriptions and budget. If PIs from more than one institution are involved, one institution should be identified as the lead, and the other institution should normally be indicated as a sub-awardee. If both institutions are on equal status and indicated as a lead, separate proposals from each institution are generally required. However, the separate proposals may be "linked" and reviewed together as a collaborative proposal. Before proceeding in this manner, it is best to communicate with the program officer managing the proposal submission process and clarify the collaborative approach. Collaborative proposals should be identified as such on the title or cover page. Often, agencies will encourage and have separate programs and procedures for reviewing and evaluating collaborative proposals.

7.5.2 Abstract, Executive Summary, or Project Summary

All grant proposals will include either an abstract, an executive summary, or a project summary, with the exact title depending upon the specific agency or organization to which the proposal is being submitted. The information included here provides the reader with a brief synopsis of what problem is being addressed, and the specific research to be pursued. This is a very important element in the proposal, equal in importance to the project description or narrative section, since the information provides the program officers and reviewers with their first impression of your research and what you propose to contribute to advance the topic. Also reviewers, when

finalizing their review and evaluation, will often refer to the information presented here to remind themselves of the main contribution described in your proposal, so the information may also serve as their last impression of your proposed research. The abstract or summary should be carefully prepared, and generally only one page in length, and no more than two pages at most. The abstract should explain the key elements of your research project in the future tense in order to project what you propose to accomplish. That is, the proposed research is based upon established concepts, but you propose to advance the area by contributing new research, which is presented in the narrative or project description section and outlined in this section. Abstracts or executive summaries will state the significance of the problem that is being addressed, the specific goals and objectives of the proposed research, as well as how the research will be performed. The main point is to explicitly and briefly describe the problem that is being addressed, and clearly state what is new about the research that is being proposed. Often it is best to include explicit statements such as "The goal of this research is to investigate. . .," or "The objective of this research approach is to demonstrate a new. . . ." Many principal investigators will put these statements in bold type to make them obvious to the reader. Reviewers generally appreciate these enhanced statements.

The NSF requires that the proposals submitted to them include a project summary, rather than an abstract or executive summary. The NSF limits the project summary to one page. The proposal should include a section titled "Project Summary" that explicitly addresses two separate areas: (1) Intellectual Merit, and (2) Broader Impacts. It is very important to briefly and effectively include separate paragraphs addressing these two components since these areas serve as the basis for the proposal evaluation and are directly addressed by the reviewers. Intellectual Merit is generally not difficult to describe, since this is the main point of the proposal, and proposal writers generally do a good job in this area. The Intellectual Merit description contains the information generally included in a normal abstract or executive summary, and describes the significance of the research problem being pursued, and

exactly what research contribution will be achieved. However, the Broader Impacts portion is more difficult to address, and many proposal writers either fail entirely to address the issue, or include an incomplete or sketchy description. While I've never seen a proposal receive an excellent rating and be accepted for funding based solely upon the Broader Impacts criterion, a good plan to address this area often makes the difference between acceptance and declination for high-quality proposals with equally rated Intellectual Merit descriptions. The Broader Impacts criterion must be addressed, and in a meaningful manner.

The Broader Impacts section does not contain information related to the performance of the proposed research, but rather to its significance and how it relates to other areas. The NSF Grant Proposal Guide clarifies what should be included in the Broader Impacts description through a series of questions intended to illustrate the criterion. For example: "How well does the activity advance discovery and understanding while promoting teaching, training, and learning?" "How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)?" "To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships?" "Will the results be disseminated broadly to enhance scientific and technological understanding?" "What may be the benefits of the proposed activity to society?"

The NSF also states that "Broader Impacts may be accomplished through the research itself, through the activities that are directly related to specific research projects, or through activities that are supported by, but are complementary to the project. NSF values the advancement of scientific knowledge and activities that contribute to the achievement of societally relevant outcomes. Such outcomes include, but are not limited to: full participation of women, persons with disabilities, and underrepresented minorities in science, technology, engineering, and mathematics (STEM); improved STEM education and educator development at any level; increased public scientific literacy and public engagement with science and technology; improved well-being of

individuals in society; development of a diverse, globally competitive STEM workforce; increased partnerships between academia, industry, and others; improved national security; increased economic competitiveness of the United States; and enhanced infrastructure for research and education." Many colleges and universities have established programs to address diversity and STEM education issues, and many successful PIs will coordinate and collaborate with these programs and describe their involvement in their NSF proposals. Also many successful PIs will recruit undergraduate students, as well as students from underrepresented minority groups to participate in the research they propose. The NSF encourages this approach and, in fact, offers additional financial support earmarked specifically for these activities. Once you receive an NSF grant, you should contact your program director and inquire about these enhancement opportunities, as they represent an excellent opportunity to expand your research activities.

When preparing the project summary in an NSF proposal, separate sub-sections should be written for and titled (1) Intellectual Merit, and (2) Broader Impacts. It's best to start each section with the words, the "Intellectual Merit of the proposed research is. . .", and the "Broader Impacts of the proposed research are. . .." Again, many PIs will place the words "Intellectual Merit" and "Broader Impacts" in bold type, which is a good idea.

7.5.3 Table of Contents

You may, or may not, be required to include a table of contents. However, it's a good idea to include a brief table of contents to indicate where major sections of the proposal are located. If you submit your proposal through the NSF FastLane system, the table of contents will be automatically generated by the system.

7.5.4 The Project Narrative, Project Description, or Statement of Work (SOW)

The project narrative, project description, or statement of work section is the main component of the proposal and is the place in the proposal

where you provide an explanation of the research topic being pursued and where you define and present the new research that is being proposed. The exact title for this section will vary from funding agency to funding agency. For example, NSF calls this section the "Project Description," while most mission agencies, such as the DOD, DOE, NASA, NIH, etc., call this section the "Statement of Work." However, no matter the requested title for this section, essentially the same information needs to be provided. Information presented in this section lists and describes all essential and technical requirements for the effort to be performed, including standards to be used to determine whether the requirements have been met. This information is very important and constitutes the real substance of your proposal. In this section you will explain your research topic, why it is significant, what previous research has been performed, and exactly what new research you intend to perform, as well as how you plan to approach the project. This section is the heart of your proposal and needs to be very carefully written. Most reviewers will spend the majority of the time they devote to your proposal reading this section, along with the project summary or abstract. Many funding agencies will often place a limit on the number of pages that may be devoted to this section, so you need to very carefully explain your research in a concise and effective manner. For example, most mission agencies and other grant funding organizations will typically limit your proposal to no more than 12 to 15 pages, depending upon the funding organization. This page limit applies to the project description or statement of work section, and doesn't generally include information associated with references cited, contributor biographies, budget details, or other supplementary or facilities explanations and descriptions, etc. The NSF limits the project description section to no more than 15 pages.

The project description or statement of work section may require, and often will include, several subsections. In particular, for proposals submitted to the NSF, if you or your co-principal investigators (co-PIs) have previously been awarded NSF sponsored grants, or if the proposal is being submitted for additional support for a follow-on project, a synopsis of the previous results needs to be included in a clearly titled subsection. Other information typically included in separately titled subsections

could include an introduction, a literature review, supporting or background information explaining the significance of the research problem, and a subsection devoted to describing the proposed research and related details, including a description of how the project will be performed. The latter material is the most important, and the other subsections are included in order to set the stage for the new research that is actually being proposed. Therefore, the preliminary subsections do not need to be lengthy, and only the material necessary to inform the readers and reviewers of what they actually need to know in order to understand what is actually being proposed, and the significance of the research, should be included. The main emphasis of the project description section should be directed towards explaining the proposed new research.

For proposals submitted to mission agencies, separate subsections may, or may not, be used and separately titled. Separate subsection titles, if placed on separate lines, take up precious space, so often the separate topics will simply be placed as separate paragraphs, or the title can be the first words of a new paragraph, with the subsection title words highlighted in bold type. However, for proposals submitted to the NSF, separately titled subsections should be used. As mentioned, if you or your co-principal investigators have previously had NSF sponsored research grants, or your proposal is being written for a follow-on grant for additional support to continue research on a particular topic or project, you need to include a synopsis of no more than five pages in length, which describes the research results you have already achieved on the previous research. This material should be placed in a separate subsection and clearly titled "Results from Previous Research." This synopsis, which is mandatory to include, applies to NSF grants received with a start date within the past five years from the date you are submitting the new proposal. This requirement applies to each PI and co-PI listed, regardless of whether the previous grant support was directly related to the research defined and described in the new proposal. If you or your co-PI(s) have received more than one NSF award during the five-year period, each PI need report only on the one award most closely related to the research described in the new proposal. The following information must be provided: (1) the NSF award number, amount, and

period of support; (2) the title of the project; and (3) a summary of the results of the completed work, including accomplishments, supported by the award. The results must be separately described under two distinct headings, "Intellectual Merit" and "Broader Impacts." It's best to place these titles in bold type to make them readily apparent to the reviewer. You should also provide a list of all publications and presentations that resulted from the previous project. If the new proposal is for renewed support, a description of the relation of the completed work to the proposed work should be included. Reviewers will be asked to comment on the quality of the prior work described in this section of the proposal, so you want to briefly, but effectively, describe the previous research.

Since the project description section is limited to no more than 15 pages, the space devoted to the results from previous research will limit the pages you have to describe the new research you are proposing. The previous results material constitutes background for the research you are proposing, so you need to strike a careful balance between explaining what has already been accomplished, and what you are proposing to accomplish. Of course, you can limit your description of the results from the previous research in order to have more room to describe your proposed research. Reviewers generally are far more interested in the proposed research, so you should include only brief descriptions of the previous research, taking care to highlight important results, in order to have more space to include details that will enhance your description of the proposed project.

You should plan your project description, project narrative, or statement of work section carefully. Since the first sentences of this section serve as the first words that the reviewers will read, it is very important to briefly and effectively include an introduction to your research. The reviewers want a clear understanding of your research problem and topic. Therefore, the introduction should cover the key elements and points of your proposal. You should include a brief and clearly written statement of the problem that you are addressing, making sure to state and emphasize the significance of the problem. You should also indicate previous work on the problem, either your own research, or that performed by others. You should cite references to indicate the most

significant advances of the past research that have been reported. This information provides background and rationale for the research you are proposing and establishes the need and relevance of the research and your approach. It is best to describe how your research differs from previous research on the same topic, but extends and advances the topic. You should also present a brief plan for how you propose to manage your project and perform the research. Finally, you should include some anticipated research results to indicate the nature of your proposed contributions. List only the principal goals or objectives of your research in the beginning of the project description and save sub-objectives for the latter part of the section. You want to indicate your problem and its significance at the beginning of the section so the reviewers will understand your problem, and then give them more details later, after they have had time to basically acclimate to your proposal.

You should include and provide an explanation for the timeline and expected performance period of your research project. In particular, indicate major milestones when critical advances or stages of the research will be initiated and completed. Reviewers will appreciate this information being provided in the form of a graphic, with major advances and items identified and listed on a vertical axis, and the performance period, usually time indicated in months, listed on the horizontal axis. Solid lines can be used to indicate expected periods of performance and related progress. This information can be briefly presented in this type of format, which presents a clear and visual presentation of the proposed timeline for your research project. This type of information can help reviewers understand your research goals, and provides them with confidence that you have clearly planned your research project and defined realistic milestones and goals.

One additional point relates to the inclusion of figures, graphs, diagrams, or tables. Inclusion of this type of graphics-based material is very important and enhances the presentation of the proposed research. This type of material can also enhance your ability to present effective arguments in an efficient manner. The old adage that "one figure is worth a thousand words" is definitely true, and inclusion of graphics-based data and visual information minimizes the number of

words that are required to provide effective and focused arguments. In particular, graphics give the reviewer a clear understanding of trends, performance predictions, limitations, etc., and helps them understand the significance and importance of your proposed project. This type of information is particularly important for science and engineering proposals. You should try to put background information, projections, predictions, etc., in figures, graphs, or tables. Also, these can be located in the proposal using a multi-column format, which permits easy integration of the graphics and text, and helps you stay within the 15-page limit. The very best proposals that I have read made extensive and effective use of this type of presentation format.

7.5.5 References and Literature Review

You should include references to published research that is applicable to your proposed project. This information should be in a separate section titled "References," and all references should be numbered and identified in the text in the project description, project narrative, or statement of work section. The references section does not generally count in the page limit restriction, so there is little reason to minimize the number of references. You should carefully document the background material you include with references, which can refer to your own published research, or that published by others. However, only reference previous work that directly relates to your proposed project, either by supporting the significance of the problem you are addressing, or by providing information that relates to your proposed solution and approach. The reviewers will generally not carefully read this material, but want to see properly referenced proposals since the references provide an indication that you are fully aware of the most significant related work that has been published and reported and that you are fully aware of your research topic, the identity of your competitors, and what approaches they are pursuing.

Some funding agencies and organizations may require that proposals submitted to them include a literature review. The purpose of this requirement is that program officers and reviewers want to know whether

you've done the necessary preliminary research to fully understand the subject you are addressing, and that you are completely aware of the state-of-the-art in the field and understand the main approaches and results that have been reported. This gives the reviewers confidence that you are prepared to perform the research presented in your proposal. A literature review, if required, should not be lengthy or exhaustive, but rather selective and critical, including the major publications and reports on the subject. Reviewers also want to see your evaluation of relevant research on projects that relate to your proposed research.

7.5.6 Personnel Biographies

The professional contributors who will work on the project should be identified in the personnel section. Everyone identified as a principal investigator (PI) should have a brief biography or CV of no more than a few pages included. The NSF limits the personnel biography to no more than two pages. Mission agencies will often not place a limit on the number of pages for the biography, but it is always best to keep it to less than five pages if a limit is not indicated. Overly long biographies can be distracting for reviewers, and counterproductive for the proposal author. In the biography the PI's current position should be listed, as well as a list of all the individual's previous academic and professional positions. The brief biography should also include a list of publications, presentations, patents, professional reports, etc. This will normally not include a complete list of the individual's publications, and should be truncated to include only the publications most closely related to the proposed research, with priority given to recent publications. For proposals submitted to the NSF, an additional list of a small number of examples that demonstrate the broader impact of the individual's professional and scholarly activities should be included. This list typically will include examples of the individual's efforts that were directed towards activities that address the broader impacts of the PI's research, such as the integration and transfer of knowledge, innovations in teaching and training, including the development of course materials and pedagogical methods, the development of research tools, the creation of computation

methodologies, the development of databases to support research and education, and activities that broaden the participation of groups underrepresented in STEM. Also, service to the professional scientific and engineering community outside of the individual's immediate organization, including significant positions or offices held, should be listed. Examples include service as an Editor-in-Chief or Associate Editor for a professional journal, service as a Chair or organizer for a major professional conference or workshop, and other service that indicates professional stature.

Other personnel who will participate in, and contribute to, the research should also be identified, generally by name and position, but if no one has yet been identified or recruited, the position and purpose should be identified. A brief description of the staffing requirements and the details of what they will contribute to the research should be provided, along with a recruitment plan for new staff. These contributors will generally be listed as Other Personnel.

7.5.7 Budget and Budget Justification

A detailed budget that describes the expenses you determine to be required to perform the research must be prepared and included in the proposal. The budget is generally prepared for a year at a time, and a separate budget will be prepared for each year of the overall project period. For example, if a three-year project is being proposed, the budget will include separate budgets for each of the three-year periods, as well as a budget sheet that includes the totals for the entire project period. Permitted items that can be included in the budget are defined in the proposal guidelines published by the funding agency and generally also in the specific call for proposals or funding opportunity announcement. For proposals submitted to the NSF, information regarding allowable budget items can be found in the Chapter II of the NSF Grant Proposal Guide (reference listed in Section 7.5), and additional information can be found in the NSF Award and Administration Guide (https://nsf.gov/pubs/policydocs/pappguide/nsf16001/aag_index.jsp) regarding the allowability of the costs of certain budget items.

The budget will provide details for all expected project costs, usually listed in a spreadsheet or table, with each budget item listed as a line item. For proposals submitted to NSF through the FastLane website, budget items are entered into a spreadsheet template, and the correct budget format is automatically generated. The budget will be separated into direct and indirect costs (sometimes called overhead costs). The direct costs include the time committed to the project and salaries for all labor categories of personnel that will participate in the project, supplies that will be used on the project, travel to program reviews and conferences to present papers, travel to visit program managers or collaborators, costs to publish papers that describe progress achieved on the project research, tuition, benefits and fee expenses for students employed on the project, and any other item that is to be directly supported from the research funds. The indirect costs refer to charges that your institution collects for permitting the research to be performed. The items and services that colleges and universities can charge as indirect expenses are defined in the US government cost recovery principles described in the Office of Management and Budget Circular A-21 (https://www.whitehouse.gov/omb/circulars_a021_2004).

For research projects that are supported by US government funding agencies, the exact amount that can be charged for indirect costs is generally a percentage of the direct costs, a rate which is negotiated between your institution and the agency that is authorized to negotiate for the US government (called the cognizant agency). The majority of organizations will negotiate their indirect cost recovery rate (ICR) with the Federal agency that provides the preponderance of their funding. For the majority of colleges and universities the ICR is negotiated with the Division of Cost Allocation (DCA) in the Department of Health and Human Services (HHS), or the Office of Naval Research (ONR) Indirect Cost Branch, with each particular academic institution assigned to one or the other of these two organizations. These agencies review your institution's financial records on a periodic basis, and the indirect rates generally change slightly with each review. Your university research office or dean's office will make the current rates available to proposal writers, as well as provide a list of allowed charges for various budget

items that are permitted to be charged to the research project. The total annual project budget will consist of a sum of the direct costs and the indirect costs, plus any equipment included in the budget. Generally, it is not permissible to charge indirect costs on equipment purchases, so these charges are listed as a separate charge after the indirect costs have been calculated and listed. For multi-year proposals, approved inflation increases are generally included for the second and third years of the project budget. Your research administration office or your dean's office will generally have this information available.

The budget should also include a narrative, or description, of how the requested budget funds will be used. In particular, the budget narrative should justify the need for the various budget items, and provide an explanation of how the various items are important for the performance of the research. The Call for Proposals, or other grant funding opportunity announcement, may, or may not, specifically request a budget justification. However, even if the proposal guidelines do not specifically mention a budget justification narrative, you should include a brief explanation of the budget. Generally, only a one- or two-page budget justification is satisfactory. The NSF, in fact, limits the budget justification to no more than three pages. Your budget justification should be brief, and clearly state the need for various budget items. Justification should be provided, in particular, for any equipment or instrumentation items you propose to purchase, or travel you plan associated with the research. Travel to conferences or other visits for reasons associated with the performance of the research is permitted, but needs to be explained and justified. Also, many agencies require details concerning travel to conferences at the time of proposal submission, and this requirement can be a challenge since conference details are often not available a year or more in advance. For these trips you will need to identify the conference, and then estimate the expenses. It is best to include such expected travel in the budget, described in generic terms, since it is difficult, often requiring agency approval, to modify the budget to include the travel after a project has commenced.

7.5.8 Current and Pending Support

Funding agencies require a listing of all current and pending research grants and financial support that you and your co-PIs have been awarded for the five-year period preceding the date you submit your proposal. In this list you should also include the current proposal that is being submitted. There are basically two reasons for this requirement: First, funding agencies want to ensure that the major participants identified in the proposal are not overcommitted and that the sum of their research effort commitments, including the proposed research, does not exceed 100%; and second, to determine that the proposed research project does not overlap with research supported on other projects or funded by other grant funding sources. That is, the sum of all the current and pending effort commitments, expressed as a percentage, for all the major participants in the proposed research project may not exceed 100%. Also, the same research project cannot be separately funded by different agencies, unless they each agree to partly fund portions of the research. However, the funding agency program managers need to be informed of all sources of funding provided to the project. All current and continuing research project financial support that you and your co-PIs have been awarded, even if you receive no salary support from the listed projects, from all sources, including Federal, State, local or foreign government agencies, public or private foundations, and industrial or other commercial organizations, must be listed. Information that should be listed includes the project title, the dates of performance, the number of person-months per year devoted to the project, and the identity of the funding agency.

The same proposal may be submitted to separate funding agencies, but the proposal should be separately listed for each agency to which it has been submitted. Also, each funding agency needs to be informed of the duplicate submission. Funding agencies will include a section for identifying other agencies to which the proposal has been submitted. Submission of the same proposal to multiple agencies is not something that should necessarily be avoided. For example, if one, or both, of the

funding agencies decide to fund the proposal, they will either ask that the proposal be withdrawn from the other agency, or they may, at their discretion, contact the other agency, and if both want to fund the research, they may agree to co-fund the research, with each agency providing a portion of the requested funds. However, in this case, there will be no increase in the amount of funding provided, and the PI will need to report to both agencies.

7.5.9 Facilities, Equipment, and Other Resources

Funding agency program managers, as well as reviewers, want to verify that the research presented in the proposal can actually be performed. Particularly for experimental research that may require access to laboratories, equipment, or instrumentation not generally available, this can be a major issue. Therefore, information related to the availability and adequacy of all necessary laboratory facilities and other resources that can be used to perform the proposed research needs to be identified, listed, and explained. If the research is to be performed in existing laboratories, equipped with the equipment and instrumentation necessary to perform the research, the laboratory facilities should be described. Often universities will operate and maintain common laboratories that are available to all faculty members and their students. Normally, a fee is charged for access and use of these facilities. The available equipment and instrumentation related to the proposed research project should be identified and described, along with the access rules, including the fee structure and operating rules. If safety training is required, this should also be explained. Basically, the proposal writers should include a brief, but complete, aggregated description of the internal and external facilities and resources, both physical and personnel, that will be available to the PIs and their students to perform the research. If the proposed research primarily requires computer resources, the available computing facilities should be described. Often, only PC-based computing will be required, but if access to supercomputer facilities is required, how this access is to be acquired should be explained, whether the facilities are local, or if access through a US government facility or other organization is planned.

7.6 The NSF CAREER Proposal

The NSF Faculty Early Career Development (CAREER) Program is a special program designed for, and directed towards, support of the development of young faculty members early in their careers. As stated by NSF, the "CAREER Program is a Foundation-wide activity that offers the National Science Foundation's most prestigious awards in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research within the context of the mission of their organizations." The CAREER Program is directed towards assisting young faculty members in building a firm foundation that will assist them in establishing a lifetime of leadership in integrating education and research. The CAREER Program is not a research program in the typical sense, but rather an integrated program consisting of both research and education, with the overall goal of helping the faculty member establish a life-long professional plan. The CAREER grant is awarded for a period of five years, with a dollar amount of a minimum of $400 000 distributed over the five-year period. The actual amount varies by NSF directorate, so you need to check with the particular directorate to which you plan to submit your proposal to determine the amount. You should plan your budget to be exactly the amount that the directorate provides, as a budget over the defined amount can result in your proposal being rejected, and an amount that is less can cause delays, and the need to modify your budget until it's in compliance with the permitted amount. More information regarding the NSF CAREER Program can be found on the NSF website (http://www.nsf.gov/career).

A CAREER award is considered very prestigious by both the NSF and the academic community and, as a result, the program is highly competitive. Many universities will routinely boast of the number of their faculty members who have received CAREER awards, and will advertise and distribute information related to their CAREER awardees. For a young faculty member the receipt of a CAREER award is a major achievement and is highly valued. It is also a great accomplishment and asset that is considered as a very positive factor

in the promotion and tenure process. Therefore, a very large number of new faculty will submit CAREER proposals. Unfortunately, the large number of proposals in any given competition, coupled with a slowly increasing NSF budget, results in fairly low success rates, which vary by directorate, but typically range between 10% and 20% for the CAREER Program.

Young faculty members generally do not fully understand the differences between a regular research proposal and a CAREER grant proposal, and focus their proposal primarily upon their proposed research activities. This is a major mistake, and often results in the proposal being declined. In this section, I'll explain the NSF CAREER grant proposal in some depth, focusing upon what needs to be included.

7.6.1 Differences Between an NSF CAREER Proposal and a Regular Research Grant Proposal

The major difference between an NSF CAREER grant and a regular research grant proposal is that the CAREER proposal is not a research project proposal, but rather is a career development award. Your proposal must reflect this focus. The proposal should describe a path to a future career, not a specific research project. You need to determine your research path in terms of your lifelong research goals, and then identify milestones to reach your goals. The first one or two of these goals will serve as the research projects for your CAREER proposal. The research goals will involve the integration of research and education activities, and although the overall goal is a lifelong plan, the milestones and integrated research and education plan need to be defined and structured for the five-year period of the NSF grant in order to establish the viability of the plan. However, the overall goals should project into the future.

All CAREER proposals must be structured with an integrated research and education plan. Although it is understood by NSF program directors and the proposal reviewers that there is no single or best approach to an integrated research and education plan, they want you to think creatively about how your research will interact with your education activities.

They want to see creative approaches and plans that will effectively couple research with education. There are, of course, different expectations within various disciplinary fields and organizations, and a wide range of research and education activities may be appropriate for the CAREER program. When planning your activities, you should address three basic questions: (1) Where are you today, and what have you accomplished? (2) Where do you see your future and what do you want to accomplish in five, 10, or 20 years? (3) How do you plan to get from where you are today to where you want to be in the future? In formulating your career plan you should consider your expertise and interests, your career goals, and your position and the resources that are available to you. Your CAREER proposal should be consistent with your goals. Your CAREER proposal should also be compatible with your home institution's goals, and your CAREER plan should represent a contribution to society at large.

Structurally, the CAREER Program grant proposal has the same major elements discussed in Section 7.5, and the proposal will be submitted through either the NSF FastLane or Grants.gov websites, and must follow the guidelines presented in the NSF Grant Proposal Guide (GPG). If Grants.gov is used, the same basic elements as required for NSF FastLane submission will be used, as discussed in the NSF Grants.gov Application Guide, which is available on the Grants.gov website or the NSF website (http://www.nsf.gov/publications/pub_summ.jsp?ods_key=grantsgovguide).

The basic elements of the proposal are as follows.

- A cover sheet
- Project summary
- Table of contents
- The project description
- References cited
- Biographical sketch of the principal investigator
- Budget and budget justification
- Current and pending support
- Facilities, equipment, and other resources

- Additional supplementary documentation required for CAREER proposals

Each of these elements is separately prepared and entered into the website template, and the website will automatically generate the complete proposal in the NSF proposal format.

Major differences between the CAREER proposal and a regular research proposal are primarily in the PI eligibility, the proposal cover sheet, the project summary, the project description, and additional supplementary documentation required for CAREER proposals. The cover sheet must contain the word "CAREER" in the proposal title, followed by the descriptive title of the proposal. The descriptive title should briefly, but concisely and accurately, represent the substance of the contents of the proposed research.

The other differences are discussed in the following subsections.

7.6.2 Eligibility

Junior faculty members at all CAREER-eligible organizations are permitted to submit CAREER grant proposals. The term "junior" faculty member refers to both tenure-track Assistant Professors, and those in an equivalent rank. There is no citizenship requirement. Proposers must hold a doctoral degree by the proposal submission date, and be employed in an untenured position at the time of proposal submission. They must continue to be untenured until at least October 1 following the submission date. They must be employed at an organization located in the USA, its territories or possessions, or Puerto Rico, that awards degrees in a science, engineering, or education field supported by the NSF. Faculty members at the rank of Associate Professor, with or without tenure, are not eligible to compete for CAREER grant awards. Scientists and engineers employed by non-profit and non-degree-granting organizations such as museums, observatories, or research laboratories are also eligible to compete for CAREER grants, providing they satisfy the other eligibility requirements. The NSF especially encourages CAREER grant proposals from women, members of underrepresented minority groups, and persons with disabilities. A PI may submit only one CAREER grant

proposal in any given year competition, and they may submit proposals in up to only three CAREER grant competitions. After the third CAREER grant proposal submission, a PI is no longer eligible for any future CAREER grant competitions, even if none of the three proposals that has been submitted in previous competitions was successful. A PI may receive only one CAREER grant in their lifetime, no matter how many times they change employment locations. However, it is permissible to transfer a CAREER award from one institution to another if the PI changes institutions. In this situation, both institutions, as well as the NSF, must concur and approve the transfer. There is no limit on the number of proposals that can be submitted from a given institution.

7.6.3 The Project Summary

The project summary should be very carefully written and structured. The NSF limits the project summary to one page, and this restriction must be respected. You should write your project summary in basically four paragraphs. The first paragraph should address your research, and the paragraph should contain statements that briefly and clearly state your long-term research goal, the research objective of your CAREER proposal, and a description of the approach you intend to follow. The second paragraph should address your education plans. You should include declarative sentences that state your long-term education goal, the education objective of your CAREER proposal, and a description of the approach you propose to follow. The third and fourth paragraphs will present the required statements addressing Intellectual Merit and Broader Impacts. Those paragraphs should begin with the words Intellectual Merit and Broader Impacts, and it's best to highlight these words using bold type. Experienced reviewers expect to see the project summary information in the described format, and using any other approach will likely result in a degraded rating for your proposal.

7.6.4 The CAREER Grant Proposal Project Description

The project description section is the main element of the proposal, just as it is for a regular research grant. However, there is a fundamental

difference in the content and approach described in the project description for a CAREER grant and for a regular research grant. In particular, the CAREER grant project description needs to contain a complete and detailed description of your long term *career* plan, including both your research and education objectives. The description needs to be carefully written, particularly since it needs to describe both the research and education plans, as well as set out how they are to be integrated. Just as for regular research grant proposals, the project description section is limited to no more than 15 pages. The project description should contain a well-developed and detailed plan describing activities that will, over the five-year project period, establish a foundation for a lifetime of contributions to research and education. The project description should address four major areas, consisting of: (1) a description and plan for your proposed research project, including preliminary supporting data and results, where appropriate, and the detailed plan to achieve the overall goals, along with the expected significance of the anticipated results; (2) a detailed description of your proposed educational activities, including plans to evaluate their impact on students and other participants; (3) a description of the integration plan detailing and explaining how the research and educational activities are integrated with one another; and (4) a synopsis of the results from previous NSF grants, if applicable. The previous results synopsis is limited to no more than five pages, just as for regular NSF research grant proposals. Also, it is not necessary to include separate descriptions of research and educational activities if they are inter-related in such a manner that the overall program can be described as a structurally integrated and interdependent program.

Your proposed research should be original and directed towards a significant problem. Projects that address incremental advances should be avoided, and proposals that contain only incremental approaches are not generally successful. Research is a process of discovery where there is a structured and determined effort to learn something that is not already known. Scientific, engineering, and educational research is always an extension of an established and known knowledge base, and the scientific method is orderly, repeatable, and verifiable. You should

state your research objective clearly, and in a manner that leads the reader directly to the conclusion that your approach will lead to the desired result. The best research proposals will begin with a clear and concise statement of the problem that is being addressed, and then provide a brief description of the state-of-the-art, including references to document major and significant advances that have been reported. You should address four critical questions that experienced reviewers will have in mind and will be expecting you to answer. First, the reviewers want to see a clear explanation of what your proposal is addressing. That is, what research problem are you addressing, and why is it significant? For CAREER proposals, as already stated, you need to include clear and concise statements of both your research and educational objectives. Second, the reviewers need to have confidence that your approach to your proposed research and educational objectives will be successful. You want to make sure the approach that you present in your proposal is realistic, and leads naturally from the statement of the problem to the desired goal of logical and successful advancement in the research topic area. They also want to know that you have the necessary laboratory facilities, equipment and instrumentation, computing access, and other resources necessary to perform your proposed research. Third, the reviewers need to have confidence that you are prepared to perform the proposed research project. In particular, they want to see some preliminary results or data that give an indication that you are on the correct path, or other background information that supports your approach. Fourth, you want to help the reviewers form an opinion of the overall value of your proposed research, and the scientific contribution that you will be pursuing. Basically, they will have the fundamental question: "Is the research worth pursuing?" You should address this question in the Broader Impact statement.

Your proposed education plan can involve a very diverse and broad range of activities, and should be directed towards the involvement of other groups of people on levels ranging from K-12 students, high school teachers, undergraduates, graduate students, and the general public. You need to have an outreach plan that will engage one or more of these groups. Typical activities could include involving other people in your

research using new tools, laboratory methods, novel learning techniques, and other approaches. These activities should be related to your proposed research, and should be directed towards outreach and involving other people in your research. You want to be able to bring the excitement of your research to help, and hopefully inspire, the education of others.

You also want to seek new methods to deliver your research results to a broader audience than those in your immediate research community. Often, many colleges and universities have established active outreach programs that routinely recruit and engage people from secondary schools, college undergraduates, students from minority and underrepresented groups, students with disabilities, etc., in campus educational and research activities. These programs will often include activities such as summer research camps for K-12 students, secondary teacher camps and seminars, teacher interns helping in your research program, and other similar activities. Many CAREER applicants will direct their educational activities to these programs, and integrate their program with that of their college or university. This type of leverage is encouraged and represents an excellent method to develop an effective education program that naturally integrates with their research activities. Your education program should be both innovative and creative. Finally, you should also include a plan for evaluating the effectiveness of your integrated education and research program. The development of a set of practical metrics for this purpose would be considered a plus. A truly novel and innovative education program, effectively integrated with your research program, will be very positively received by the reviewers.

7.6.5 Additional Supplementary Documentation

For the CAREER program, the NSF requires that your department head or department chair provide a support letter stating institutional commitment to support you as you pursue the career development plan described in your CAREER proposal. The letter can be no longer than two pages. If you have appointments in more than one department, the head or chair

of the department that will grant you tenure should sign the letter. However, if tenure is to be granted in more than one department, the letter must be signed jointly by the department head or chair of each department. Only one support letter will be accepted. This support letter is mandatory, and proposals submitted without this letter will be returned without review. The letter needs to commit to provide institution support for the PI's proposed research and education activities. The letter also needs to provide a description of how the PI's career goals and responsibilities are consistent with the department's goals and priorities. Your department head or chair must also commit to support your professional development with mentoring, and provide support and resources that may be necessary in order to assist you as you implement your research and education plans, along with their integration. The letter also needs to explicitly state that you are eligible to participate in the CAREER program.

Letters that indicate collaboration are permitted to be submitted, but are not mandatory, and proposals without these letters will be accepted. The letter of collaboration would be written by other scientists, engineers, or professionals, generally from other organizations outside your institution, and with whom you intend to collaborate as you pursue your CAREER project. The letter of collaboration is limited to stating the intent to collaborate. Letters of recommendation from collaborators are not permitted, and the collaborator should not provide an opinion of the quality of the proposed work, the quality of the PI, or comment otherwise upon the proposed project. Also, a letter of collaboration should be in a single-sentence format. That is, the letter should simply state that, if the PI's CAREER project is selected for funding, the author of the letter intends to collaborate on the project, or commit resources as detailed in the project description. If collaboration is planned, the details, including an explanation of the need for, and nature of, the collaboration and the intellectual contribution the collaboration will bring to the project should be described in the project description. Also, permission to use a collaborator's facility, including laboratory, equipment, instrumentation, and any offer by the collaborator to provide samples and materials for research, logistical support to the

research and education program, or mentoring of students, should be described in the project description. The collaborator's position and organization should be indicated, but nothing else should be in the letter. Letters from multiple collaborators are permitted.

7.6.6 The PECASE Award

The Presidential Early Career Award for Scientists and Engineers (PECASE) is an honorary program, and is considered to be the highest honor the US government confers upon outstanding scientists and engineers in the early stages of their independent research careers. The agencies participating in the PECASE award program are: the Department of Agriculture, the Department of Commerce, the Department of Defense, the Department of Education, the Department of Energy, the Department of Health and Human Services, the Department of the Interior, the Department of Veterans Affairs, the Environmental Protection Agency, the Intelligence Community, the National Aeronautics and Space Administration, the National Science Foundation, and the Smithsonian Institution. The number of PECASE awards for each agency is proportional to their basic research budget. PECASE awardees must be employed by or funded by one of the participating agencies, and they must be US citizens or permanent residents and have received their PhD degree within five years of the nomination. The NSF selects its PECASE nominees each year from the CAREER awards that they consider the most innovative, creative, and meritorious. Selection of the PECASE award nominations is based upon two criteria: (1) the innovation of the research, which is considered to be at the frontiers of science and technology relevant to the NSF mission; and (2) the involvement in community service of the CAREER grantee, as demonstrated through scientific leadership and community outreach. The CAREER awardee does not apply for a PECASE award, and the nominations are selected by the NSF. There is no monetary award involved with the PECASE program. The final selection and announcement of the PECASE awardees is made by the White House Office of Science and Technology Policy.

7.6.7 Common Mistakes

There are several common mistakes that many PIs make in preparing their proposals, and these mistakes can degrade the ratings that they receive and result in their proposal being declined. These mistakes are easily avoided. The most common mistakes, as identified and stated by reviewers, are as follows.

- Ignoring the rules presented in the NSF Grant Proposal Guide. If these rules aren't followed, your proposal has a high probability of being returned without review. The NSF is not lenient on the failure to follow the rules.
- Planning the proposed research and education on too broad a basis.
- Planning the proposed research and education on too narrow a basis.
- Basing your proposed research upon an incremental advance.
- The proposed research plan is not likely to yield results that will successfully meet the goals of the project.
- The research project methodology and design are flawed and not well designed.
- The resources needed to perform the research are either not available or are inadequate to perform the research described in the proposal.
- Submitting an unrealistic budget by making it either too large, or too small. The budget needs to directly correlate with the work described in the proposal.
- Focusing the research program on development efforts, computer programming, commercialization, or design. Where possible, avoid words such as "develop," "design," "optimize," or any other word that distracts from "research." The proposed work needs to be focused upon fundamental research and scientific discovery.
- Failure to include an adequate education plan, or presenting an education plan that is generic, and proposing to do what is normally expected of any PI in your field.
- Failure to demonstrate knowledge of education problems or to demonstrate understanding of what is effective in education.
- Failure to provide a realistic integrated research and education program. Also, paying inadequate attention to the education program component of your career plan.

- Failure to include outreach or engage with K-12 students, undergraduate students, or students from underrepresented minority groups.

7.7 What to do if Your Proposal is Declined

Let's assume the worst case scenario. You've followed all the proposal preparation guidelines, sought and received advice from experienced proposal writers, and prepared and submitted what you consider to be an excellent proposal, only to be informed that your proposal has been declined. What are your options, and what should you do? First and most important, don't become frustrated or disillusioned. Having a proposal declined is always disappointing, but it happens to everyone, including the very best researchers. You want to learn from this experience and be better prepared for your next proposal submission. Therefore, you want to know the reasons for the decision to decline your proposal, and find out what deficiencies were identified, and what you need to do to correct them. If you submitted your proposal to the NSF, the summary of the panel review is available to you on FastLane. However, the panel summaries generally contain only a brief, and sometimes unsatisfactory, synopsis of the panel discussion. The summaries generally do not include detailed critiques, or indicate in detail how the proposal can be improved. Comments addressing these issues will be in the summaries, but, in general, they will be cursory. If your proposal was submitted to a mission agency, you may have received minimal information regarding the proposal review, and possibly have simply been informed of its declination.

Your first step should be to contact the program director or program manager who was responsible for reviewing your proposal. If you submitted your proposal to a mission agency, the program manager is, most likely, the person to whom you sent your proposal. If the proposal was submitted to the NSF, it was assigned to a program director, and he or she selected the reviewers that participated on the proposal review panel. The NSF program directors are organized in their respective divisions according to subject and topic area, and the program director you should

contact is the person who has responsibility for your research subject, and the program director who communicated with you regarding your proposal. When you contact them, you should request a debriefing on the reviews and evaluations your proposal received. They will provide you with information regarding the discussions relative to your proposal. However, it is not likely that you will receive a significant amount of information regarding the panel or reviewer evaluations, and you won't be given any information that could reveal the reviewers' identities. The debrief information generally provided to proposal writers tends to be fairly general, although occasionally specific critiques will be provided, particularly if some obvious and glaring deficiencies were noted in the proposal. This type of information is easy for the program manager or program director to report. In fact, this is the main information you are seeking. You want to know what the reviewers considered to be any major weakness or deficiency, and particularly if the same weaknesses were noted by the majority of the panel members, or only one or two reviewers. This is the most important information that will help you make improvements for your next proposal and, in particular, you will want to address and correct deficiencies or weaknesses noted by multiple reviewers.

Proposals will naturally fall into three groups; excellent proposals, weakly developed or poorly written proposals, and those in between. The first group will be rated highly by the majority of reviewers, and these proposals will be kept in the competition. The second group will be lowly rated by most reviewers, and will essentially be eliminated from the competition. The third group is the most difficult to review, and often will receive mixed evaluations, ranging from fairly high to fairly low, with most ratings somewhere in the middle. The review panel will discuss the middle group of proposals in some detail, and will end up with an overall evaluation and rating for each proposal. The issue is that sometimes mistakes are made, particularly by reviewers with a general knowledge of the research area, but without intimate knowledge of the proposal subject area. This is the reason that you would want to know if weaknesses were noted by multiple reviewers. If a weakness is stated on a concept presented in the

proposal, and particularly if you do not agree with the reviewer, you may very well be correct and, in this situation, you should definitely not make any changes. Reviewers serving on proposal review panels have been known to make mistakes. For example, I've served on several proposal review panels where I've heard a particular reviewer say something like "This work is not new, it's already been done and reported," when, in fact, the work described in the proposal has not been done, and the research is expanding a very important area. These types of mistakes sometimes are not caught during the panel review process, and can result in a proposal declination. In this situation you do not want to make any changes since a proposal submitted to future competitions will be reviewed by different reviewers.

You need to keep in mind that there is always a limited budget for any particular grant funding competition, and only a limited number of proposals can be selected and funded. In fact, most competitions receive a large number of proposals and the rivalry can be intense. This results in many proposals that receive high ratings not being selected due to a lack of available funding. However, funding agencies require that reasons be stated for each proposal selected, as well as for each proposal that is declined. To satisfy this requirement, there will be statements entered into the proposal evaluation for highly rated, but not selected, proposals to justify the declination. These statements do not generally provide information that will be useful for future proposals.

For proposals that are submitted to mission agencies and declined, the debriefing by the program manager provides an excellent opportunity to learn more about his or her particular program and what research topics are being supported. Your proposal may have been declined since the program manager did not feel the subject effectively fit into his or her particular program. Your proposal may have been, in fact, high quality and worthy of support, but was not selected due to lack of interest by the program manager. You want to learn as much as possible about the program manager's research program and try to align your proposed research to topics in which they have interests.

7.8 What We've Learned

In this chapter we've discussed issues related to proposal preparation, submission, and the review process. We've also discussed how proposals are reviewed within various grant funding agencies, and noted that some agencies will send proposals to selected reviewers where the proposal will be independently reviewed, while some agencies make almost exclusive use of review panels. However, all proposals will receive multiple evaluations, and will be reviewed by three to five reviewers, and sometimes more. We're learned that proposal reviewers are your colleagues and all are professionals and highly trained in their respective fields. Experienced reviewers learn how to read and evaluate a proposal quickly and efficiently, and they will look for certain critical information. This information is stated in four fundamental principles, that should be followed; know your subject, learn how to write your proposal for the intended funding agency and its reviewers, make sure to read the details of the Call for Proposals, or other grant funding announcement, and include all requested information, and follow all stated procedures so that your proposal is not summarily rejected.

The components of a basic proposal were defined and discussed. The importance of preparing a brief and effective abstract, executive summary, or project summary, in which you present a description of your proposed research and your research plan was indicated. The main component of the proposal is the project narrative, the project description, or the statement of work section. The NSF CAREER proposal was separately discussed, since this program differs in a major way from a normal research grant proposal. That is, the NSF CAREER program is not solely a research program, but is a long-term career development program, and it requires an integrated research and education program. Finally we discussed your options in the event your proposal is declined. In particular, it's very important to contact the program manager or program director to learn the issues that resulted in the declination of your proposal. In this manner, you want to learn how to correct any deficiencies and address any weaknesses in order to improve your prospects for future success.