

Writing
Successful
Science
Proposals

Andrew J. Friedland and Carol L. Folt

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Preface

One of the most challenging aspects of scientific research is synthesizing past work, current findings, and new hypotheses into research proposals for future investigations. Such research proposals combine every aspect of scientific inquiry, from the creative conceptualization to the detailed design, projected analysis of the data, synthesis of the results, and estimation of the budget. Because grant applications are an articulation of the scientific process, writing them is one of the most exciting parts of “doing science.” If you are planning to write a grant application for a major foundation, such as the National Science Foundation, the Environmental Protection Agency, or perhaps a private foundation, or if you are writing a proposal to conduct research as a graduate student or undergraduate, this book should be of value to you.

Many research institutions offer graduate-level

courses on proposal development, and research design is growing increasingly vital in the undergraduate science curriculum. Given the importance of this subject to future scientists, our faculty in ecology and environmental studies at Dartmouth College felt that it was essential that we create a course on scientific project design and proposal writing for our graduate students. In 1994, when we began teaching the course, we could not find a text that specifically addressed grant writing in the natural sciences. So we decided to write one ourselves based on our experiences in the classroom. We hope that our book will be of value not only to students but also to new researchers seeking to improve their skills in developing research proposals.

This book provides guidance for those conceptualizing and formulating their research plans, and it offers specific instruction on organizing and presenting material in a standard format. We offer an overall organizational framework, and we list the components of successful scientific proposals. Before you begin to write, you must have a very clear idea or concept for your research. There is, however, no secret formula for writing such proposals. Each grant application must be tailored to the specifications of the funding agency or graduate committee to which it is directed.

Research proposals are written for a variety of

purposes and are submitted to many different agencies and to faculty committees. We focus on agencies that solicit proposals in the natural sciences; these include the National Science Foundation (NSF), National Institutes of Health (NIH), Environmental Protection Agency (EPA), U.S. Forest Service (USFS), U.S. Geological Survey (USGS), and private corporations and foundations, as well as academic committees. Our format should also be useful to those submitting to the National Research Council of Canada, NATO Scientific and Environmental Affairs Division, and other funding agencies worldwide.

There are many ways to write excellent proposals. We present a model that we and our students and colleagues have used with success. Our ideas have been combined with those of the many natural scientists from a variety of disciplines with whom we have consulted while writing this book. Discussions with colleagues, proposals given to us by successful authors in a variety of fields, and our students' ideas have been especially meaningful in this effort. If you submit a proposal after using this book, or if you use this book in a course, please let us know how you fare. We look forward to hearing from you.

Acknowledgments

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A Note to the Reader

We recommend that you read this book in its entirety before beginning a project. Then review chapter by chapter—not necessarily in sequence—as you develop specific sections of your proposal. The following list contains a number of goals that you can realistically expect to accomplish over the course of preparing a research proposal.

- Identify and describe the conceptual framework for the research question.
- Review the relevant theoretical and empirical literature both for the system being studied and for related systems.
- Articulate the general research question in the context of the conceptual framework and the theoretical and empirical work that precedes the proposed work.

- Formulate a set of hypotheses to address the general question.
- Design studies to test each hypothesis.
- Develop methods and techniques to test, analyze, and synthesize results.
- Evaluate potential alternative outcomes that may be obtained from each part of a study, and consider where each of these alternatives may lead.
- Combine these items in a coherent, precise, concise, exciting proposal.
- Submit the proposal to the appropriate agency or evaluation committee.
- Interpret and respond to reviews of the proposal.

This primer contains a collection of chapters that address our dual goals of assisting development of research ideas and of providing detailed guidelines for writing grant applications. We present the material in much the same order we use in teaching our course, *Design and Development of Scientific Proposals*, and in designing our own research proposals. We first discuss general types of proposals and share thoughts

about writing research (Chapters 1 and 2), and then we outline the basic elements of a proposal (Chapter 3). We address the conceptual framework (Chapter 4) and how and where in the grant to articulate succinctly the study's importance. In Chapters 5–13, we address the requirements and construction of the specific elements in a grant proposal (summary, background, methods, budget). We conclude by presenting the mechanics of submitting and tracking a proposal, and by sharing some thoughts about ethics and scientific research (Chapters 14–16).

Getting Started

We vividly remember the intense anticipation that we felt as children at the start of a new school year. Filling our notebooks with stacks of crisp white paper, sharpening our pencils, and buying new books were exciting in large part because we were starting fresh. Anything could happen, and it all could be good! The start of a new year, a new job, a new class, or a new project is a special time, when you feel as if you can accomplish anything.

For many scientists, designing research carries that same sense of exploration, excitement, and unlimited opportunity. For this reason, it is often a scientist's favorite endeavor. As you begin your research proposal, we urge you to:

THINK BIG. Reflect on your problem from its broadest perspective. Imagine finding innova-

tive solutions to fundamentally important problems. If you start small, your work will end up even smaller.

AVOID TUNNEL VISION. Consider projects that could lead to years of research. Enjoy a time of intense creativity, and—at least for a while—think beyond your immediate research area.

DREAM. Dream about solving important problems, making a difference, producing significant papers, even winning a Nobel Prize.

TAKE YOUR TIME. Great ideas do not appear in thirty-minute windows of time. When designing a research project, expect to spend lots of time on it. You will.

Planning research can be stressful. Anxiety arises when we focus too much on what people will think of our work. We all have periods of insecurity, when we mistakenly believe that everything rests on the outcome of one specific project. People often fret about how their advisers or peers will evaluate them. They worry about their research questions: “Will I think of a question important enough to keep my interest and warrant my attention for years to come?” They feel uncertainty about the outcome: “Will my research

idea work?” “Will it lead to publications?” Try not to be overly concerned. Many people experience this when they feel pressured to identify problems.

Reducing the insecurity and uncertainty associated with developing a scientific proposal fosters the excitement and innovation that lie at the heart of science and research design. Here are some simple steps to ease yourself into the process:

- *Define tasks associated with the proposal.* Don't make the list too long or too inclusive at the start, or it will be discouraging.
- *Develop a timeline or strategy for working on your proposal.* Try working backward from your deadline to get a reasonable idea about when specific tasks must be accomplished. Make sure that you have sufficient time.
- *Accomplish something early.* Complete a few tasks quickly. We give our class a set of short- and long-term deadlines at the start of the term. (And we'll present a few examples later in this chapter.)
- *Remember that the best proposals are built from the best science.* Effective proposals require a sound scientific basis. Articulating and developing a logical framework for the problem are

the key elements in the success and power of the research. Therefore, time spent developing ideas is well spent. Some researchers believe that the best problem solvers are individuals who understand the need to get the initial question right (Runco 1994).

- *Relax, and be prepared for change.* Nothing is fixed. You will think and rethink everything throughout the proposal's development.

Exercises for Getting Started

We use three exercises to initiate proposal development. These tasks are not meant to be accomplished in a single sitting but should be pursued concurrently: critique other proposals; accomplish administrative and technical tasks; work on the conceptual framework of your research.

Critique other proposals. Established scientists routinely review the proposals of students and colleagues as part of the peer review process. This gives them a sense of the scope and size of a research proposal. Assessing other research proposals is also a po-

tent method of learning science and focusing on both the broad implications and the methodology behind research. It is general policy that reviewers destroy proposals after reading them, but most scientists will share their own successful and unsuccessful proposals with peers and students. Do not hesitate to request such assistance from a colleague.

As you read proposals, consider the following major criteria: scientific content, innovation and scope of ideas and methods, structure and format, clarity, and style. Reviewers for the National Science Foundation or other granting agencies may be asked to consider the following while evaluating a proposal: scientific importance of the question(s), rigor of hypotheses, feasibility of research design, qualifications of the investigator, and suitability of facilities for the proposed work.

Our class begins with a discussion of proposals that we have written or that have been given to us by our colleagues to share with the group. Using the title, project summary (or abstract), and significance sections, we question whether the author has convincingly justified the proposed work. We discuss methods, graphics, and style and ask whether the work captured our attention. At some point we try to compare each proposal with others we have read. This discussion is meant to be

a starting point; eventually everyone develops individual style, methods, and measures for evaluating proposals.

Accomplish administrative tasks. Completing administrative and technical tasks is another effective way to get started. Begin by reading the proposal guidelines and requirements for the potential funding agency or foundation, or the guidelines issued by your department. Fairly early in the process you should put together a simple outline identifying the key sections of the final document (see Chapter 3). Think about optimal lengths for each section. This activity will probably put you at ease because you will quickly realize that most grant applications are usually concise—fifteen single-spaced pages is the maximum for NSF; many other agencies have the same page limit (dissertation improvement grants, offered in some programs within Environmental Biology at NSF, are limited to eight pages).

Another important task is determining an institution's procedures for grant processing. Ask questions such as, "What paperwork must I complete?" "What signatures do I need?" "Where do I go?" "How much time should I allow?" "What are the institution's rules on budgets, overhead costs, and cost sharing?" "Do I need special permission for anything?" (e.g., ani-

mal care, use of human subjects). These seemingly mundane points are critical, as poor planning may result in a scramble to meet due dates, or, worse, missed deadlines.

In the past few years, granting agencies have begun to accept electronic submissions, and many do now or will soon require such submissions. For example, many U.S. NSF programs require electronic submission through a program called FastLane. This program allows a researcher to prepare the budget and submit the proposal over the World Wide Web, and it saves on expensive processing and paperwork. As you collect information for submitting a proposal to your potential funding agency, be sure to learn about the requirements regarding electronic submission.

Develop your conceptual framework. Conceptualizing your research is the most substantial step in preparing a proposal. Some people work on their ideas for months or years before they actually begin to write. Others, especially students, pull together their ideas only when they are required to write their first research proposal. In our proposal development class we spend several weeks working to produce a succinct statement of the overall concept that can be understood by a broad scientific audience (see Chapters 4–7). This

statement is the foundation for the rest of the proposal (see Chapters 8 and 9).

Know Your Audience

Grant applications are written for a variety of purposes and are submitted to many different types of agencies. Before you begin writing, consider the fit between your research goals and the targeted agency. Agencies have various reasons for announcing a Request for Proposals (RFP) or establishing a program that will periodically accept proposals. In this book we focus on such agencies as the National Science Foundation (NSF), National Institutes of Health (NIH), Environmental Protection Agency (EPA), U.S. Forest Service (USFS), U.S. Geological Survey (USGS), and private corporations and foundations. For the most part, we discuss basic research proposals, in which the investigator sets out research questions and goals. Agencies sometimes set the goals, however, and request proposals to address a particular objective, research target, or initiative. Accordingly, we separate proposals into two general categories:

- 1. Basic research proposals** (unsolicited research proposals), which generally must provide novel

insights or methodologies for solving fundamental scientific problems (see Chapter 4).

2. Task-oriented or program-initiated proposals are those in which the topic or goal of research is specified by an agency, a corporation, or a foundation.

There is usually less latitude in determining research topics than for basic research proposals. Proposals are evaluated on their likelihood of accomplishing the specified task, so emphasis is placed on methods, ability to accomplish the project, credentials, the projected outputs, and time needed to complete the project. (These criteria are also important in basic research proposals.)

Once you have identified a specific program or agency and become familiar with the guidelines, talk with the program director or manager (the person in charge of evaluating grants in that program). Do not call until you have definite questions. Avoid open-ended queries, such as, “What kind of proposals do you fund?” Take notes during the conversation. Discuss the goals and general format of your project and ask such questions as, “Does my proposed research fit within

the mandate of your program?” “Is there a related program that you think would be better suited to evaluate my project?” There may be unwritten requirements for successful grants that you need to clarify with the program director. For example, you may wish to address a question by comparing data from diverse regions around the world, but the agency may be interested only in questions about a particular region. The program manager can clarify such issues relating to the scope of the program. Be sure to ask about spending limits, restrictions on equipment purchases and investigator salaries, and other financial regulations. (See also Chapter 13.)

It is also appropriate to ask the program manager about the review process. Find out the backgrounds of the scientists who will evaluate your application. By knowing your audience, you can anticipate their questions and address likely concerns in the proposal. For proposals that cross disciplinary boundaries, this information is critical. When conducting interdisciplinary research you will need to address the concerns of individuals in each discipline. Discussions with the program director and with scientists in the pertinent fields will save you much time and effort and could make the difference between success and failure.

Other Exercises for Getting Started

- Distinguish tasks that can be accomplished in one or two days from longer-term chores.
- Find at least one set of proposal guidelines. This can be accomplished by contacting the office on your campus that handles the submission and administration of grant awards, surfing the Internet for agencies' guidelines, or borrowing from a colleague or adviser. See the Web addresses for funding agencies in appendix 2.
- Begin to identify specific sections required in the final proposal and to list the elements they should contain.