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## CHAPTER 2

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# How to Write a Research Proposal

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**Benefits which cannot be repaid  
and obligations which cannot be discharged  
are not commonly found to increase affection.**

Tacitus (A.D. c. 55–c. 120).

**R**esearch proposals are of course required by funding agencies, but graduate students usually must submit a formal proposal of thesis research, and there are other occasions upon which established scientists must write proposals. This chapter explains how to prepare and submit a research proposal, using the Dissertation Improvement Grant format of the National Science Foundation as a specific example. Discussed are the criteria used to evaluate a proposal, the usefulness of testing your plans on others before submitting, the importance of pilot studies and preliminary data, details of the content of a proposal, and various tips and suggestions. The heart of any kind of proposal is tripartite:



Explain what you want to do, how you will do it, and why it is important.

It is usually assumed that a disorganized or poorly written proposal reflects a disorganized or poorly conceptualized study. Therefore, organization, content, and clear writing are essential to the success of a proposal, whatever its purpose. This chapter concentrates on organization and content; Appendix A is devoted to clear writing, applying equally to research proposals and other exposition. Even if no funding or prior approval is required, the rigor demanded by articulating your knowledge of a subject and your research intentions can help you to identify inconsistencies in logic and inappropriate fits between the questions you ask, the data you intend to collect, and your methods. Describing what you plan to study, how you will do so, and why it is important is a vital, and in many instances mandatory, precursor to conducting scientific research.

Successful scientific proposals convey good salesmanship: you are selling a future product, your research idea and protocol, to a critical audience that must select from among many such products. To sell your proposal effectively, you must know who your audience is, whether they are highly trained specialists in your field, established researchers in related fields, or board members seeking research that is consistent with their foundation's funding

directives. Persuasive writing does not compensate for scientific competence, but many good ideas and research designs are undermined by explanations that are either too vague or too specific to the audience evaluating them.

## Format

Funding agencies and university graduate programs may differ in their format and content requirements for scientific proposals. A proposal to a conservation or biomedical foundation will require a different emphasis than one to a behavioral society. Before beginning to write, you should obtain all of the available information and forms from all of the funding agencies or programs to which you expect to submit proposals (see Appendix B for prominent U.S. granting organizations and their World Wide Web access). Books listing funding agencies can be found in the reference sections of most university libraries. These guides to grants and foundations include the addresses and phone numbers of funding sources, as well as summaries about the programs. You will need to write or call to request application materials, which usually take 1 to 2 weeks to arrive.

All federal grants and many private ones will require approved animal care protocols. So simultaneously with soliciting grant information, also begin looking into laws, regulations, and guidelines applicable to use of animals in research. A good place to begin is the unit on your campus that approves animal care protocols. Furthermore, many professional societies – among them the Neuroscience Society, American Psychological Association, Animal Behavior Society, and Ecological Society of America – publish guidelines on animal use and other ethical concerns.

When you receive application materials from the granting source, read the instructions carefully, paying particular attention to:

- the number of copies you will need to submit
- page limits
- funding criteria and amounts available
- deadlines
- supporting documents

Supporting documents are such things as letters of recommendation, academic transcripts, evidence of collaboration, and research

permits. It may be useful to create a computer spreadsheet that you can skim at a glance to keep various deadlines and required supporting documents organized. There is nothing more frustrating – or impeding to research – than discovering at the last minute, after completing your proposal close to deadline, that you will need a document that requires lead time to obtain, or that you neglected to allow time to reproduce twenty copies of a proposal. If any information in the requirements is unclear, be sure to contact the program's funding officer directly. Getting help prior to submission, either to clarify ambiguous instructions or to guide you as you write, will greatly alleviate unnecessary disappointments.

Here we use the standard Dissertation Improvement Grant proposal's format of the National Science Foundation (hereafter NSF) as our model for preparing proposals. Not only is NSF one of the primary sources of funding in behavioral biology and related disciplines, it also requires one of the most detailed proposal contents. Learning how to write a competitive NSF proposal will help you in other fund-raising efforts because, once completed, the proposal can be adapted to other funding sources.

Unlike scientific journals, which expect to be the sole evaluators of a submitted manuscript, most funding agencies encourage multiple submissions to various sources and ask you to state whatever sources you have applied to in the event of any overlap in budgeted items. For example, only certain programs at NSF (e.g., animal behavior, ecology, anthropology) have the Dissertation Improvement Grants for field studies, but many agencies and even some private foundations have similar programs. For instance, the National Institutes of Health (NIH) has programs for predoctoral fellowships.

Whatever grant is being applied for, follow precisely all the instructions, including those for specific format. A very important set of instructions is that relating to the length and format of sections, especially the heart of the proposal where you explain hypotheses to be tested and methods to be used. Federal granting agencies in particular may specify not only a page limit but also the minimum size of margins and the size of fonts for the text. In general, a single-spaced proposal is best formatted in a 12-point font whereas a double-spaced proposal can be put in 10-point. Remember that reviewers are inevitably overworked persons who must read a number of proposals in a short period; do everything possible to make your proposal easy to read.

## Criteria for Evaluation

Each funding agency has its own criteria for evaluating proposals. Scrutinizing these criteria before you write or adapt your proposal will help you to avoid off-target or inappropriate submissions. Some funding agencies provide written evaluations when they announce their results, others will discuss the reasons for a negative decision if they are asked, still others provide little or no feedback even on request.

The cover page of an NSF proposal asks you to identify the area under which your proposal falls. When it is processed, the proposal will be sent to the program officer in that area, who will ask multiple reviewers to evaluate your proposal anonymously. These reviewers receive a copy of your proposal, which they are expected to treat as a confidential document, and a list of criteria for evaluating your proposal.

The criteria used by reviewers may change from submission to submission, so it is wise to verify what the current criteria will be. Many foundations and agencies make available to investigators printed information concerning how their proposals will be reviewed. The following criteria come from an uncopyrighted booklet published by NSF, entitled *Grant Proposal Guide* (designated NSF 95-27 on the outside front cover and NSF 95-64 on the inside). Direct quotes are from this booklet. This and similar free documents may be obtained by writing to NSF Forms and Publications Unit, 4201 Wilson Boulevard, Room P-15, Arlington, VA 22230 (see also Appendix B for contacting NSF and other funding sources). At present, NSF directs reviewers to consider the following four items in their evaluation. The NSF announced intentions to revise these criteria in 1997, but new guidelines had not yet been released when this book was completed.

### 1. Research performance competence

"This criterion relates to the capability of the investigator(s), the technical soundness of the proposed approach, and the adequacy of the institutional resources available."

Is the investigator capable of carrying out the proposed research, and is the approach that will be taken technically sound? Evidence of pilot studies and preliminary results will be especially

useful to help beginning researchers establish their credibility and capability, and should be included whenever possible. The technical soundness of an approach will be apparent if the study involves well-established methods of data collection and analyses. Nonetheless, it is critical to select methods appropriate to the kind of data that will be needed to address the study's goals. A mismatch between questions and methods can undermine a proposal's credibility. If sophisticated methods will be employed, references or letters of collaboration from appropriate laboratories or investigators will help to justify your rationale. Application or development of new techniques will require careful and detailed documentation of their suitability and viability. Often the most difficult, and potentially devastating, feature of a proposal is the use of new techniques that reviewers are unfamiliar with or skeptical about.

Foreign research requires some special demonstrations of feasibility. It is almost imperative that the researcher has had previous experience at the field site and can demonstrate that the proposed methods will work. Local monies and small grants from private foundations should be sought for support of pilot studies abroad. Furthermore, the applicant's plans are more likely to get sympathetic attention if she or he can state fluency in the local language where field work will be done.

## 2. Intrinsic merit of the research

"This criterion is used to assess the likelihood that the research will lead to new discoveries or fundamental advances within its field of science or engineering, or have substantial impact on progress in that field or in other scientific and engineering fields."

What is the likelihood that this study will lead to new discoveries or fundamental advances within the field? This criterion evaluates the heart of the proposal: how the research proposed fits into and extends or clarifies existing knowledge in the field. It encompasses the background and justification for the research, the general objectives and specific hypotheses, and the ways in which data will be interpreted. As in the first criterion about research methodology, any mismatch between data interpretations and hypotheses, or the relevance of hypotheses to the general goals, will raise questions about the likelihood that the research will ultimately contribute new information to the field.

### 3. Utility or relevance of the research

"This criterion is used to assess the likelihood that the research can contribute to the achievement of a goal that is extrinsic or in addition to that of the research field itself, and thereby serve as the basis for new or improved technology or assist in the solution of societal problems."

What is the likelihood that the research will contribute to goals extrinsic to the research and therefore be the basis for new technology? Here the reviewers will be looking for the broader impact of a study. Whereas behavioral studies may only rarely lead to new technological developments, they can (and should) nonetheless be relevant to larger questions. Imagine trying to justify the importance of a study on bird territoriality or monkey-feeding ecology to an economist or political scientist, or even your grandmother. Think broadly here, perhaps in terms of understanding aggression or seasonal nutritional stress, to identify and "contextualize" your study within a larger more comparative framework. Interdisciplinary studies or integrated field and laboratory approaches can be similarly justified.

### 4. Effect of research on the infrastructure of science and engineering

"This criterion relates to the potential of the proposed research to contribute to better understanding or improvement of the quality, distribution or effectiveness of the Nation's scientific and engineering research, education, and manpower base."

In all honesty, neither of us authors has ever understood this criterion. It was not until we began collaborating on this book that we discovered each of us had been leaving the item blank when serving as reviewers for NSF proposals. One of us had, several times, written a note on the reviewer's sheet asking for clarification, but no response was ever forthcoming. Perhaps there is a lesson here that might be stated thus: sometimes not even experienced investigators understand every detail of grant proposal instructions.

One of our colleagues interprets the "infrastructure" item of NSF as referring to the education and training of students by their mentors. In other words, how will undergraduate and graduate education in science be affected by the awarding of this grant?

Also note that this "infrastructure" item is not part of National Institutes of Health (NIH) grant criteria.

What to do about a quandary of interpretation depends upon many factors. If an isolated item seems clearly designed to apply to proposals of a distinctly different nature from the one you are writing or reviewing (as in this case), it may be safe to ignore the item as "not applicable." If there is any doubt, phone the program director and try to have the item clarified. If two or more items are unclear, then you should always seek a clarification.

## Feedback

Established scientists with high funding success routinely solicit feedback on drafts of their proposals from colleagues. It is even more unrealistic to expect a beginning scientist to be able to write a competitive proposal without extensive guidance and feedback prior to submission. Indeed, NSF Dissertation Improvement Grants (and many others) require that the student's faculty advisor sign as the Principal Investigator, indicating her or his endorsement of the proposed research.

Most faculty will not want to approve a study or a proposal unless they are satisfied with it. Therefore, even if they agree with the research topic, they will nonetheless expect to play an active role in shaping the proposal. Regular meetings should be established between you and your advisor, who should read your proposal and provide feedback, and reread revisions until the proposal is ready for submission. Working on a proposal in parts enables you to fine-tune it before investing the time and energy into a full-length draft. It may be difficult for an advisor to provide such specific feedback until she or he sees the entire proposal in writing. It is almost always the case that even then, this draft will undergo multiple revisions. As noted in Appendix A about writing in general, the rule is revise, revise, revise.

Extensive revising is a process that will help you to fine-tune your ideas and allow you to be more explicit and unambiguous in your thinking as well as your writing. Working on your grant proposal with your advisor also immerses you in the discourse of science.

It may be helpful to establish a schedule for completing sections of a proposal. Whereas an advisor should be the primary source of feedback, other committee members or colleagues should

be sought for advice and feedback as the draft develops. Such feedback is especially important if letters of recommendation from faculty other than or in addition to the advisor are required.

It is important to remember that funding is highly competitive and that many highly qualified, highly rated proposals nonetheless fall below funding limits. The National Science Foundation asks reviewers to rate proposals as *excellent* if they fall within the top 10 percent and are of the highest funding priority; *very good* if they are within the top third and should be supported; *good* if they are in the mid-third and worthy of support; *fair* if they are within the lowest third; and *poor* if there are serious deficiencies. Many very good and even excellent proposals fail to achieve funding status. In these cases it is worth contacting the program officer to discuss whether a revised submission is merited. Fair and poor proposals usually require extensive revisions to the point that a subsequent submission may bear little if any resemblance to the original.

Rejections or unsuccessful proposals are not uncommon, even among highly respected, productive, and established scientists. It is important to take reviewers' comments and criticisms seriously, but also not to let a negative review or outcome discourage you to the point of despair. Discussing your reviews – and how to improve on or modify the proposal and the research – with your faculty advisor(s) is an important component of learning how to carry out a scientific study and write a successful proposal.

Often the most rate-limiting steps to proposal writing are the turnaround times between feedback and revisions. A proposal that is the length and depth of an NSF submission may take months of formulating and rewriting; sufficient lead time and coordination between student and advisor should be allowed before submission deadlines.

## Proposal Content

This section is subdivided to reflect the different components of an NSF proposal. It may be helpful to read through the entire section before beginning to write, and then return to each topic as you reach that part of your proposal. The generic protocol described here will obviously require some modifications to fit your own research area. There are differences between field- and laboratory-based behavioral research, between observational and experimental

research, and among the kinds of questions and methods that can be applied to different species. Be sure to take these differences into account when using these suggestions to guide your own proposal.

### Significance of a title

The title of your proposal should state precisely what your study is about. Many first-time proposal writers underestimate the importance of an informative title. If you cannot state concisely what you intend to study, you may need to clarify your thinking on the subject.

One of the most common problems with titles is that they claim to cover more than the research will actually achieve. For example, a proposal titled "The Effects of Nutrition on Chimpanzee Reproduction" implies that nutritional intake and reproductive condition will be measured and correlated. Suppose the study actually involved the use of feeding observations without corresponding nutritional analyses and focused exclusively on female reproductive status. A more appropriate title to the research would then be "The Effects of Food (or Diet) on Reproduction in Female Chimpanzees."

At the same time, however, a title should not be so narrowly defined that it fails to capture the broader scientific context in which the research is situated. Correlations between variables other than diet and reproduction, such as dominance rank or age, might constitute equally important questions in the proposed research. Note the different emphases, and what each implies about the research goals, in the following possible titles:

- The Effects of Diet on Age, Rank, and Reproduction in Female Chimpanzees.
- The Effects of Reproduction on Diet, Age, and Rank in Female Chimpanzees.
- The Relationships among Diet, Rank, and Reproduction in Female Chimpanzees.

Proposals rarely fail solely due to an inappropriate or misleading title, but like all first impressions, titles set up expectations for what will follow. An accurate and informative title will help ensure that your proposal is sent to appropriate reviewers and that they will not need to readjust their expectations once they begin to read your proposal.

### Identifying objectives

What are the general goals of your study? Usually these objectives are to examine, expand, investigate, explore, develop, or evaluate a set of data relevant to a set of questions that inform the overall research. Objectives should be concise statements that provide enough detail to communicate the scientific focus of the study.

In defining your objectives, it is helpful to think in terms of three or four broad aims. These may be parallel or organized along a gradient from specific to general. A study on "Sex Differences in Territorial Behavior in a Polygynous Bird (Species)" might have three objectives: (1) to evaluate the presence and degree of sex differences in territorial defense; (2) to explore the reproductive correlates of territorial defense for males and females; and (3) to develop a model of the dynamics of polygyny. Remember, however, that you will need to elaborate on each of your objectives in the body of your proposal. Therefore, when formulating your objectives, as in the case of your title, be careful that you do not set yourself an objective that your research cannot address. Objectives, like titles, may require fine-tuning as you develop the body of your proposal.

### Integrating your research with existing knowledge

The background to your proposal provides the formal scientific context from which your study is derived and to which your research will ultimately contribute. It is a section in which you review what is already known and what the outstanding questions in your study area are. It is, in essence, a formal review that should outline, usually in the third person, what stimulated your interest in your proposed research. This section cannot be written until you have a thorough command of the literature in your field and have identified existing questions or gaps in this literature. How you focus this section - what you choose to include or omit - will depend on what your study proposes to accomplish. It is often the first part of the body of a proposal, but in relating your stated objectives to existing knowledge, you may find it helpful to begin by developing separate background sections for each of your objectives.

If one of your objectives is to evaluate an existing model with data from a new species, you will need to review the model and provide evidence for why such a test of the model is important. Exceptions that challenge the model or paradoxical features of

your study subject are examples of how you may be able to situate your research contribution within a broader context. Similarly, if one objective is to document the existence and degree of sex differences in a particular behavior, you will need to describe why you might or might not expect sex differences to occur using examples from other studies that demonstrated inconsistent patterns.

It is important to recognize that your preparatory reading is likely to be much more extensive than what you will have space to review in the background section of your proposal. It is also the case that not all of your prior reading will be equally relevant to your proposed research. Choose your examples and citations carefully, being sure to indicate whether your list is inclusive or selective. Profiling an example as being “. . . the sole exception . . .” when there are others that you fail to acknowledge will raise doubts in reviewers’ minds about your ability to integrate your proposed work with existing knowledge. The background section should demonstrate that you have a clear idea of what is new about your proposed research. Inappropriate claims about your own originality may offend reviewers who have done similar work or know of other work in the area, undermining the credibility of your proposal and assessments of your ability to interpret your data if you are given the opportunity to collect them.

### Hypotheses and predictions

The questions that you propose to address in your research will be clearer if they are framed in terms of specific hypotheses (models) and predictions. Carefully conceived hypotheses demonstrate that you are aware of how your research fits into prior theoretical or empirical work in your area, and carefully deduced predictions indicate whether your reasoning is logically sound. Examples of research hypotheses were given in Chapter 1 and others will be mentioned here. There are usually at least two alternative hypotheses that could be made for any research question raised. The basis for each set of alternatives should be provided and properly referenced. Alternative hypotheses should encompass all possible outcomes of the inquiry. When possible, they should be mutually exclusive, making different predictions. The proposal should make explicit reference to how your data will enable you to distinguish among alternative outcomes.

You may have strong reasons to believe that your data will support some hypotheses and predictions more than others, but reviewers will be looking for evidence that you have anticipated the possibility of unexpected results and are prepared to deal with them if they occur. It is legitimate to identify which prediction is most likely to be confirmed, but it is often the juxtaposition between outcomes that conform to expectations and possible exceptions that generate the most original and important results. That is, if you are 99 percent confident of a particular outcome based on what is already known on the topic, you may lead a reviewer to ask why she or he should endorse a study with such a certain outcome. On the other hand, if you devise an alternative model that makes the same expected prediction but makes other predictions not generated by the traditional model, this would be a powerful way of setting up your research.

Each of your objectives should have a set of predictions derived from existing knowledge and reviewed in the background section. If your objectives are arranged hierarchically, you may find it organizationally helpful to treat the background and associated hypotheses and predictions for each objective separately. If your research involves a series of controlled experiments, it may be simpler to write an integrated background section and elaborate on your alternative hypotheses and predictions when you describe your experimental methods. Be aware that your study's results may lead you to rearrange the way in which you present your objectives or experiments in your thesis or publications (see Chapter 3), but until you actually do the research, you must use what is already known to organize the logical development of your hypotheses.

Wherever you situate them, a critical step in formulating alternative hypotheses is to articulate the null hypotheses against which any alternative predictions are compared. In statistical terms a *null hypothesis* ( $H_0$ ) usually refers to no difference between two sets of measurements or no relationship between two variables, when research hypotheses predict such differences or relationships. The operational statement of the investigator's research hypothesis (or the prediction deduced from it) is called the *alternative statistical hypothesis* ( $H_1$ , if there is only one).

Rejecting a statistical null hypothesis such as "no difference between two groups" may permit you to conclude that a difference does exist, but it will not tell you the direction of this relationship

automatically. Confirming a null hypothesis can be highly informative. For example, larger male mammals may need to feed for longer periods than smaller females to sustain their body weight, whereas females may need to feed for longer periods due to the energetic demands of gestation and lactation. The null hypothesis in this case, that there are no sex differences in the length of feeding periods, might indicate that female reproductive requirements offset the requirements of male size. Such a conclusion could be drawn, however, only if the body size differences and reproductive states can be measured and are represented in sufficiently large sample sizes to compare (see the next section, Methods).

If alternative hypotheses are not mutually exclusive, it will be difficult to persuade a reviewer that you will be able to resolve the questions you are trying to address. For example, a set of alternative hypotheses stating that dominant females spend a greater proportion of their time feeding than do subordinates ( $H_1$ ) and that monogamous females spend a greater proportion of their time feeding than do polygynous females ( $H_2$ ) may be difficult to confirm or refute if dominant females also tend to be monogamous. Similarly, it is critical that your hypotheses fall within the scope of the data you will obtain. In the foregoing example, it may not be possible for you to ascertain the dominance rank of monogamous females because their monogamy precludes the kinds of repetitive social contests that permit such calculations. Or, it may not be possible to evaluate the effects of monogamy and polygyny on female feeding behavior because you will not have a large enough sample size for each possible case. If you cannot discriminate among all of your alternative outcomes, then restating the question and the supporting hypotheses may be imperative. Once again, if reviewers are not convinced that your data base will permit you to evaluate your hypotheses, they will challenge the feasibility of your research despite strong marks for scientific interest.

Precision in your choice of words when you state your hypotheses and predictions, and in your methods of data collection, will help avoid unintentional mismatches. A null hypothesis stating that female reproductive condition has no effect on female diets can be interpreted in different ways. It could imply that you predict no dietary differences among females, or that nonreproductive variables, such as age or rank, are more directly responsible for dietary differences between females. How will female diets be evaluated? Total feeding minutes, proportion of daylight hours spent feeding,

feeding rates, or types of food are all valid estimates of diet, and which data will be used should be specified to avoid unnecessary confusion. And, of course, it must be clear that you will be able to assess differences in female reproductive conditions, and that you will have large enough sample sizes to compare among.

## Methods

How you will obtain the data necessary to evaluate your hypotheses is as important to a reviewer as the pertinence of your questions. Using established methods whenever they are appropriate will facilitate comparisons between your study and other related research and will avoid the necessity of detailed explanations. Standardized methods or experimental techniques should be described and fully referenced. Any deviation or innovative methodology will require detailed explanation, justification, and often evidence that you have tested the suitability of the method. If you have presented preliminary results from a pilot study, either in the background section or a separate section of your proposal, you will need to explain any deviations from the methods used previously. New or controversial techniques are unlikely to impress a reviewer unless you can demonstrate convincingly that they work.

Included in a proposal's methods section should be information about your study site or laboratory facilities, the duration of the study, the unit of sampling (days, hours, minutes), and the number of study subjects you will be sampling. It is not sufficient to say that you will collect systematic data on all of the adult males and females in your study group, or on all of the groups in your study area. How many males and females or groups will compose your sample set? You may not know the precise answer to this question if you lack prior experience or information about your study population or area. Nonetheless, you can indicate what you will consider to be a minimal sample size, and be prepared to justify why you are confident that your sample size criterion can be met.

You will need to work closely with your advisor and other experienced scientists to establish appropriate sample size requirements that will be possible to meet under your particular research conditions and that will be sufficient to address your research questions. One of the most common dilemmas that we have encountered in our own research and advising experience arises from the need to choose between sampling many different individ-

uals versus sampling few individuals, but each more intensively. If too few different individuals are included in a study, it will be difficult to evaluate how much variability exists among them. Conversely, if so many individuals are included that none can be sampled with adequate frequency, it will be difficult to establish individual patterns.

Furthermore, we recommend that you consult statistics books or advisors to confirm the sample sizes you will need for particular analyses you intend to use. Experimental design is a distinct sub-discipline within statistics, often with entire university courses being devoted to the subject. Although this topic is actually just the quantitative aspects of experimental design, it is critical to good research planning. Consider a very simple but realistic example. You have reason to test the prediction that a sex ratio in some population of organisms is imbalanced. No matter what the outcome, a sample of five individuals cannot establish two-tailed statistical significance of a difference; indeed, seven individuals of one sex and one of the other is similarly not significant by a binomial test. Considering the natural variation in any biological system, sample sizes needed to evaluate a phenomenon with statistical reliability are often much larger than beginners in science realize. And if the phenomenon under study is complex, requiring multivariate statistical evaluation such as analysis of variance, the minimally adequate sample size could be enormous.

Remember that you will need to explain how you will obtain data on each variable you mention in your hypotheses. Predictions from those hypotheses need to be stated explicitly in terms of data to be collected. Definitions of categories of different food types or different types of aggressive behavior, for example, should be precisely stated. A detailed ethogram or coding system can be mentioned in the methods section with reference to a complete listing provided in an appendix. If you also intend to examine seasonal effects on one or more variables, you will need to describe how these effects will be measured, and if appropriate, what type of equipment you will use to obtain these measurements.

Consider some further questions. Will you be working alone or with assistants? How will you control for inter-observer reliability if more than one person will be collecting data? Will you require preparation time to cut and map a trail system or to habituate your study subjects? How will individuals be marked or identified? Anticipating these logistical considerations in your methods section

will indicate that you are fully prepared to conduct your proposed study. Failure to describe these details will raise questions in a reviewer's mind about whether you have a realistic assessment of what will be involved in your study, and it may negatively affect an assessment of your study's feasibility.

The methods section is also the place to describe how your data will be analyzed. Reference to particular software programs and statistical analyses is usually sufficient, but any complicated or unusual analyses should be discussed in greater detail.

Include an agenda, or schedule of research, listing when or in what sequence each phase of your project will occur. A schedule of research will permit reviewers to evaluate whether you have budgeted sufficient time to complete your proposed research. It may be the final subsection of your methods section, or a separate section following methods.

### Significance

The body of your proposal (background and hypotheses) will have already explained the relevance of your study to your main objectives. The significance section provides an opportunity to flag additional contributions that your study may make. Depending on your research, these might range from the importance of your study to conservation of an endangered species or ecosystem, to advances in technology that your methods will provide, to a multifaceted approach that will help to merge interdisciplinary fields. The significance section is usually no more than two paragraphs, but despite its brevity, it demonstrates that you have considered the broader implications of your study to science at large. A good way to think about the significance of your study is to imagine another proposal of comparable merit to your own and explain why your choice of study subjects or location or methods distinguishes yours.

### Literature cited

Unlike journals and books, scientific proposal guidelines rarely specify the format for bibliographic material. Following the standardized format described in Chapter 3 will usually be adequate. Literature cited in a scientific proposal is precisely that: an alphabetical listing of the references you cited in your proposal. Careful

cross-checking between citations and references is as important in a proposal as it is in a manuscript. (A way to do this checking using computers is explained in Chapter 3.) Be sure to take into account any page limits to this section when you are deciding how extensively you will cite existing literature in your proposal.

### Summary

The summary of a scientific proposal is the equivalent of the abstract of a research report (Chapter 3), but there is a subtle difference. Proposal summaries become part of public archives and are sometimes scrutinized by legislators or other nonscientists, a point discussed later. Many funding agencies provide a separate page with a defined space for your summary. Other agencies, like NSF, simply indicate a word limit. The summary will follow immediately after the cover page of an NSF proposal, and thus is the first part of your proposal that a reviewer will read.

A proposal summary encapsulates what you intend to accomplish over what duration and where. Like the abstract of a manuscript, it should be written only after you have finalized the body of your proposal. Repeating important sentences taken directly from your proposal is a legitimate way to structure your summary, but you will probably need to go back and edit some of the sentences so that they make sense in this context.

Because of potential nontechnical readers, proposal summaries need to be prepared with special care. Try to avoid saying things that might seem silly or trivial to a general reader. A U.S. Senator once publicly ridiculed a funded proposal in the social sciences because it seemed from the summary to be about the game of tennis. In fact, it was a serious study of frustration and anger as expressed in a defined social context, so it proposed to use observations of tennis players as subjects. Perhaps more careful wording of the summary would have helped prevent the public ridicule. Studies of animals are especially prone to misunderstanding, as they often seem to the nonscientist as somehow less scientific than studies of brain function, genetics, or ecosystem dynamics.

### Budget and budget justification

National Science Foundation proposals have a separate budget page included in their application materials. Photocopy this page

from the application pamphlet to use as a worksheet, and follow the instructions for completing it carefully. The main categories in a budget include: salaries for research personnel; research-related travel; permanent equipment; materials and supplies; and indirect costs. You will need to assess carefully the expenses associated with your research and provide an itemized explanation of costs within each category in an accompanying budget justification. The NSF Dissertation Improvement Grants have specified caps (\$12,000 in 1996) and do not include indirect costs (discussed later). It is important to verify (with the appropriate program director) whether or not a new limit has been set. Regular research grants do not have formal budget limits, but funding agencies often cut a requested budget, so it is important to think about which items might be expendable if such cuts are recommended.

Salaries must be broken down by the number of paid personnel and their percentage contribution to the research. Graduate students rarely receive salary to conduct their dissertation research under an NSF Dissertation Improvement Grant, and faculty advisors never receive salary for their advising role in a student's research. Be sure that you are fully informed about associated costs for any legitimate salaries requested. In some countries, for example, registered employees are legally entitled to vacation wages; most university employees are entitled to fringe benefits, calculated as a percentage of their time contribution to the research and enforced by university research administrations. The lag time between writing your proposal's budget and when you will actually begin your research may mean that you will have to factor in an estimated raise for your personnel for the following year. Many first-time proposal writers are unaware of the various components that determine the real cost of personnel. These costs can add up quickly, approaching the maximum funding obtainable from an agency. It is wise to be conservative and request salaries or partial salaries only when absolutely necessary.

Research-related travel can include airfare or other modes of travel between your home base and your field site or laboratory facility. It can also include travel costs associated with supply trips. Round-trip APEX airfares can be obtained from any travel agency. Federal funding agencies have strict requirements dictating the use of national air carriers, even if they are more expensive than foreign ones. Be sure you obtain the appropriate price estimate to include in your budget.

Permanent equipment is defined as any single item costing more than some criterion amount. Equipment might include such essential things as computers for data collection or analyses, or a vehicle. Universities may insist that such equipment be purchased through their own vendors, so university purchasing departments should be consulted for price listings and bidding procedures. Also be aware that the dollar criterion for permanent equipment fixed by a granting agency may differ from the definition of capital equipment used by your institution, and that both kinds of criterion values are changed from time to time (mainly to keep pace with inflation). Knowing your institution's criterion for capital equipment may become critical later, as it usually determines which purchases must be put out for competitive bidding to at least three different potential vendors. Even if an exact item is written into your budget and the proposal is both approved by your institution and funded by the agency, you may later have to endure a bidding process that typically requires 90 days.

Materials and supplies include all other expenses associated with your research. Subsistence costs, excess baggage, field or laboratory equipment, and analysis costs are usually included. It is legitimate to include any materials or supplies that you need for your research that you would not otherwise require. You will need to obtain current prices for each supply you intend to itemize (e.g., Nikon 9 × 30 binoculars, \$xxx; ten rolls of Ektachrome 400 slide film @ \$xxx + developing @ \$xxx/roll), and estimate those that you will lump together in your budget justification (miscellaneous supplies including plastic bags, aluminum nails, paper toweling, etc.).

Indirect costs are fixed by each university to cover the administrative costs of your research if it is funded. Public funding agencies, like NSF, will send your grant monies to your university, and you will need to submit requests for these funds as your needs arise. Private funding agencies may be exempt from paying indirect costs and may be willing to send you a personal check. Be careful of such income, however, because it may be reported to the IRS as taxable income and require itemized deductions. Indirect costs are usually calculated as some percentage of your total budget request and added to the final project costs. You should consult with your university's accounting office or research administration to determine whether you will need to include indirect costs in your budget, and if so, what they are.

To help guide you in your first budget and budget justification

attempt, we include an example of a \$12,000 NSF Dissertation Improvement Grant budget for overseas research. A total of \$2,290 was requested for travel, \$4,210 for materials and supplies, and \$5,500 for other direct costs. The travel justification was as follows: \$2,000 to pay for part of a round-trip APEX airfare; \$190 to pay for two trips (at \$50 each for transport and \$45 each for lodging) to consult with colleagues; and \$100 for five supply and administrative trips between the field site and the nearest town. The budget for materials and supplies included field notebooks, collecting vials, binoculars and photographic equipment, plant press, metric scale, and plastic storage bags. Each item was listed with quantity and price in the budget justification. The other direct costs covered food and lodging, indicated in the justification at the per diem rate.

### Other funding

The NSF and most other funding agencies will ask you to provide information about any other sources of funding you have already secured or have requested (or intend to request) from other sources. Only current, pending, and intended submissions should be listed. You will also need to indicate whether any of these proposals have overlapping budgets, and how you plan to deal with the possibility of duplicate funds. You may have included airfare in your NSF budget and also requested airfare from a departmental travel fund. If both requests are successful, it may be possible to rebudget one airfare into another category. In the worst case, you lose the second airfare, which presumably you did not need anyway.

### Appendixes

Documentation to support your proposal, including copies of research or collecting permits, collaborations, access to laboratory facilities, and samples of your data coding system or check sheets can be included in the appendixes. Appendixes do not replace or supplement the text of your proposal, and some funding agencies have strict restrictions on content or prohibit appendixes altogether. Appendixes may be removed before your proposal is sent off for review, so it is important that you include all essential information in the body of your proposal.

Most universities nowadays require approval of any research involving animals, and will not forward or administer a proposal or

study that has not been approved by an animal care committee. Find out well in advance from your animal care committee the laws and regulations applicable to your proposed study. For example, the Department of Agriculture sets regulations on care of captive animals in the United States, and many individual states have further laws. The Fish and Wildlife Service issues collecting permits for wild animals, and the National Biological Service controls the banding program for birds. Many professional societies issue their own guidelines for use of animals in research (for example, the Dawkins and Gosling reference listed in the bibliography at the end of this book). When you submit an acceptable experimental protocol, your animal care committee will supply a letter stating that your research conforms to national standards for animal welfare. You will need such proof even if your study involves nonmanipulative observation of wild animals. Be sure to allow time for your proposal to be processed.

Research in other countries and at some American facilities such as National Parks require permits. You will also need to verify the permit requirements if you will be capturing, collecting, or transporting any biological material (e.g., plant samples, live or dead animals, blood, urine, or feces). International transport of biological materials may be subject to customs inspections before departing from a host country and when you reenter the United States. Check with the U.S. Department of Agriculture concerning import restrictions, and with the equivalent government agency in your host country. It is also wise to verify with your airline whether transporting preservatives such as liquid nitrogen is permitted. You may not be able to apply for research permits in other countries until you have proof of your funding sources. A statement to this effect in an appendix will demonstrate that you are thinking and planning ahead.

### Table of contents

The NSF requires you to submit a table of contents indicating where each of the major items are located in your proposal. It is usually the third page (p. iii) of your proposal's front material, following the cover page (p. i) and the summary (p. ii). The guidelines specify the sequence and page limits for each component of the proposal. The NSF requests a curriculum vitae (c.v.), limited to no more than two pages, for each individual involved in the project.

For Dissertation Improvement Grants, this usually means that you and your advisor must prepare a condensed version of your c.v.'s (Tips on writing a c.v. are covered in Chapter 5.)

You will not be able to complete your table of contents until you have completed the final version of your proposal and paginated it. Subheadings within the body of your proposal should be listed even if more than one subheading occurs on the same page.

### **The Submission Process**

Once you have completed your proposal and your advisor has approved it, you will need to duplicate the required number of copies. You may need additional copies to distribute to various university offices that approve your budget and will administer the funds and, of course, a copy for yourself and one for your advisor. Express mail services provide greater security that your proposal will reach its destination by the deadline. Be sure to verify the address and phone number of the agency. Furthermore, you must send to a street address because express carriers cannot deliver to P.O. boxes.

Most funding agencies will send an acknowledgment of receipt of your proposal and any other supporting materials, such as letters of recommendation, within a predetermined time period. The NSF, which does not require letters of recommendation, may take longer to acknowledge receipt of your proposal because of the number of proposals handled. If you have not heard word that your submission has arrived, it may be worthwhile to phone the funding agency to verify that it is being processed. Most funding agencies have inflexible deadlines and will not accept overdue submissions.

The NSF reviews may take up to 6 months; other funding agencies may be faster or slower in providing a response. There is little you can do to speed up the review process for your proposal, and repeated inquiries may unnecessarily irritate program officers. You should, however, notify your program officer of any changes in plans or funding status that occur while your proposal is being considered.

### **The Review Process**

Most funding agencies will send notification that your proposal has been received. Both NSF and NIH send cards with the program

name and application number that your proposal has been assigned. The program officer responsible for shepherding your proposal through the review process will send your proposal to appropriate reviewers for anonymous evaluations. Reviewers are instructed to treat proposals as confidential documents not for distribution. You may suggest the names of possible reviewers or individuals who may have conflicts of interest regarding your work when you submit your proposal. The program officer, however, will make the ultimate decision about who will review your proposal.

In addition to these ad hoc reviewers, NSF and NIH proposals are also evaluated by two to three members of a panel that meets to consider all requests for funding during the same submission cycle. At these meetings, the ad hoc reviews and the reviews by panel members are discussed, and a funding priority decision is reached. Within a few weeks of the panel meeting, the funding decision and anonymous reviews of your proposal will be mailed to you.

If a funding decision is positive, oftentimes the program officer will contact you to discuss possible or recommended revisions to the budget. You may be asked to submit a revised budget page before your grant can be officially approved. Program officers rarely call applicants with news of a negative funding decision. However, most program officers are willing to discuss your reviews and provide advice about whether a revised proposal should be resubmitted to their panel. The program officer may reiterate concerns raised in the reviews and provide more details on the panel discussion of your proposal that will help you to strengthen a resubmission. Depending on your schedule, the status of other grants you may have submitted elsewhere for the same study, and the feedback you receive, you may decide to revise and resubmit your proposal for the next funding cycle, or wait to develop a new or substantially different study for possible funding. Even if your proposal is funded, we encourage you to consider carefully the reviewers' comments and incorporate any recommendations that make sense into your actual study.

### **What to Do While Waiting for a Decision**

Many researchers consider the interim between submission of a proposal and notification of its funding status to be wasted "down time," but we think that this is an erroneous assumption. There

are many time-consuming preparations that can be initiated during the waiting period, such as arranging purchase of supplies that require funds once you have obtained them.

If you will be working in another country, use the waiting time for preparations. Make sure that your passport will be valid for the duration of your intended study. You may need to wait until you have secured funding before applying for a research visa, but you can obtain all necessary forms and complete them in advance. Some countries require proof that you have been vaccinated against particular diseases; if you will be working with wild animals you might consider rabies and tetanus vaccinations. Consult your doctor about foreign travel, and make an appointment for a complete medical exam prior to beginning your research. You should have health insurance in any case, and it is important to verify that your current insurance policy will cover you during the period and under the conditions of your research. Familiarize yourself with the policy's limitations and liabilities so that you are prepared in the event of an emergency. If you will be working in an isolated area, you should also begin to assemble a medical kit that includes a guide to self-administered first aid. Insect repellent, a snake kit, antibiotics, and any prescription medication for allergies should be included.

You may be required to notify your university if you will be off-campus for any length of time. Often this will change your registration status and lower any fees you are required to pay. Obtain the necessary forms in advance so that you can process them as soon as you know your precise departure date.

When you developed your budget you will have discovered where to purchase the supplies you will need. Assemble order forms for each source, but be sure to verify the prices, including carrier fees, at the time you are ready to make the purchase.

You should also already have a good idea of what methods you will be using in your study, but the waiting period is a good time to practice these methods and fine-tune them as much as possible. Do you know how to use a compass, binoculars, or sound recording equipment? Borrowing the equipment and testing your use of it on local birds or mammals will save you valuable time later on. Do you have adequate experience mapping or quantifying vegetation? If not, obtain some training or practice now. Similarly, if you have designed a check sheet or coding system for recording behavioral observations, now is the time to familiarize yourself

with it. If your study involves observations of wild primates, a combination of practice sampling sessions on the same or a related species in a local zoo or on a locally occurring species, such as squirrels or birds, will help you train for your planned field study. Such training will give you greater confidence when you begin your actual research.