

# **The Anatomy and Art of Writing a Successful Grant Application: A Practical Step-by-Step Approach**

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## **ABSTRACT**

Writing a compelling grant application is a skill that is crucial to conducting high quality and high impact scientific research. A successful grant proposal provides the resources necessary to foster activity in an important area of investigation. A concise and practical overview of the anatomy and art of grant writing is provided in this article, along with citations to resources that are particularly useful for junior investigators.

## **INTRODUCTION**

Conducting significant and high-impact scientific research requires sufficient funding that covers the cost of research materials, equipment and time of researchers and staff. Research funding is usually allocated competitively, with the goal of funding research most likely to have a substantial impact. A well-written grant proposal clearly communicates the potential significance of a topic of research, the impact of the work to be carried out, and the feasibility of the research team successfully carrying out the proposed work. Researchers need to have a deep understanding of the previous and current work in the domain of interest, appropriate intellectual training, innovative ideas and goals, and a scientifically sound study design that indicates a high probability of success. Articulating a successful grant application depends on writing ability and organization skills in order to communicate the significance and impact of the proposed work.

The overarching goal of this article is to provide a concise and practical review of such skills from a grant writer's perspective.

A good grant proposal should communicate clearly by being (1) easy-to-read, (2) concise, and (3) attractive. Headlines, subheadings, and highlighted parts are helpful to convey the message. The writing itself should respond appropriately to the review criteria. It is also critical to find and identify an appropriate funding agency and review panel that matches both the science being proposed and the investigator proposing the research. We discuss such pre-writing aspects in Section 2. This follows with Section 3 that provides an overview of the fundamental anatomy of a typical grant application with highlighted points that we deem essential for successful grant writing. Then, in Section 4, we discuss specific considerations for different types of grant applications such as pilot grants, research grants, and career development grants.

In Section 5, we present considerations about the review process and review criteria. Finally, Section 6 involves the concluding remarks.

### **1. Prior to writing**

High impact research questions may arise at different points over a research career. We assume that over a period of research and training, the applicant has identified a critical need, has considered a research strategy, has formulated an overarching hypothesis and is committed to investigate the problem in detail. Throughout this process, the applicant should have thoroughly reviewed and critically analyzed the literature describing background and previous work, and performed preliminary studies to assess the feasibility of the research strategy. It is essential that the applicant critically assesses the overarching hypothesis and compares it to alternatives in the literature, and improves or modifies it if needed. Such a process leads to the proposed idea and research strategy being refined to maximize their impact. Finally, the applicant designs a research plan that is scientifically based, ethically appropriate and technically feasible. Now, it is time to write one or more grant applications to receive funds and resources that enable the principal investigator and research team to execute the research strategy. It is recommended to start the writing process at least six to twelve months in advance of the projected due date of the grant submission. Clear expression and communication of scientific ideas requires substantial quality time be assigned for writing, and time should be set aside to allow co-investigators, collaborators, and a few experienced colleagues or a mentor to go through the application and provide feedback. Preparing a realistic work plan and a detailed timetable is always helpful and often leads to ultimate success.

Prior to writing a grant proposal, it is important to find a funding agency or institution that offers the funding opportunities that fits the main idea or purpose of the research project. Ideally, the overall objective of the proposed project is an ideal fit with the agency's mission and the project can help the agency achieve their main goals. Sometimes, a request for applications (RFA) or a program announcement (PA) fits well to the project. On the other hand, it is strongly discouraged to try to invent a project or substantially change a project to fit a funding stream such as an RFA. While finding a good funding opportunity is an absolute necessity, the latter is considered chasing funding (i.e., money) which is inappropriate and often waste of precious time. The search may vary based on the type and size of the project and should include a wide spectrum of available national and international institutes, societies, and foundations [1-5].

## **2. Anatomy of writing a grant proposal**

The fundamental anatomy or different sections of a grant proposal is often defined by the specific funding agency or institution. However, it typically involves common components that are discussed in this section. These are general descriptions that need to be tailored to each specific grant application. Therefore, in this review, we refer to available resources for grant writing [6-11] as well as scientific communication [12, 13] and only mention the essential points that we deem necessary to be emphasized.

### **a. Title, abstract and summary**

Clearly conveying an easily understandable, scientifically valuable, and technically achievable main goal of the research proposal to the reviewers is essential for the ultimate success of the grant application. Such information should be effectively included in the title, abstract, and summary of the grant application. The abstract, or project summary, is a stand-

alone section that should be interpretable by a layperson, and at the same time clearly communicate the essence of the project. The project summary explicitly describes the overall objective, significance, contribution, innovation, specific aims, and the positive impact of the project. As a consequence, the project summary is often the last section that is written in a grant proposal. In fact, it can be written by putting together the highlighted parts of the main sections of the proposal.

### **b. Objectives and specific aims**

For many grant applications, the goals of the project can be described in hierarchy. The statement of goals may begin with a long-term overall objective which describes the ultimate aim of a body of research, including the proposed project. Then, shorter term goals describe gaps in knowledge or techniques and critical needs that should be addressed. Lastly, they end with a set of specific aims that will fill the gaps and address the critical needs. It is important to recognize that the value of the long-term overall objective is often as important as the specific aims in the requested funding period. The main reason is because it defines the significance and long-term impact of the project. The relationship between achieving the overall objective and the specific aims is a key point to be clearly and logically written. Therefore, three main points are often described in the objectives/specific aims section: (1) overall objective: what will be possible after this project, which is not currently attainable?, (2) rationale: why do we want to do this? (i.e., identifying the critical need and gap in knowledge or technique), and (3) specific aims. The most important aspect of the specific aims is that they are a clear statement of the objectives and milestones of the research that together address the overall objective of the proposed study. They provide a series of experiments that will be carried out, the successful execution of which conclusively addresses a specific aspect of the overall objective. They provide an answer to the

question “What are you going to do?”. The details of the execution of each of the specific aims are provided in the research strategy section of the proposal.

Within the specific aims, a set of hypotheses and a central hypothesis are defined to be tested in the study. The central hypothesis is presumably the narrowest testable outcome of the proposed project in the funding period. Thus, it should be explicitly defined in the objectives/specific aims section and other sections of the proposal as the single over-arching question that needs to be answered. An hypothesis must be based on evidence, supported by preliminary data, compatible with the established facts, and lead to observable consequences that are readily tested. The evidence, facts, tests, and alternatives should all be discussed in the research approach sections of the grant proposal. Finally, by definition, a hypothesis should be written in a form such as “the central hypothesis is that A causes B,” rather than “the central hypothesis is if A causes B,” or “the central hypothesis is to prove that A causes B.” The words “if” and “prove” are contradictory to the definition of a hypothesis.

It is also often helpful to include statements about the investigators and why they are the best research team to perform the proposed research by explicitly linking to their expertise, background, track record and previous work. Finally, the objectives/aims section can be concluded with a statement or paragraph about the deliverables (i.e. the expected outcomes of the research which is in line with the mission of the funding agency). Explicit statements about the positive impact of the research and the return for investment always enhance the chance of receiving a positive decision from the funding agency.

### **c. Background and significance**

Since the proposed research project and hypotheses are based on scientifically sound evidence and knowledge about the specific field, the project's background, literature, and active projects/grants should be thoroughly communicated to the reviewers. This review should be concise but must also be comprehensive with appropriate citations. Ideally, all the related references should be provided so that the reviewers don't need to search for related material on their own. With the current pace of research, it may be particularly important to describe related activity being carried out through ongoing multi-institutional studies or clinical trials in the background review.

Significance defines the main positive impact of the research project on the subject related to the mission of the funding agency. The significance section often comprises three main components: (1) the identification of a gap and critical need through background and literature review (with appropriate citations), (2) the expected contribution to address the critical need and the significance of the contribution through focused, highlighted statements, and (3) the positive impact of the project. It is critical to convey in several key places of the grant application what the research community and the funding agency should expect from the grantee for the investment. This should be clearly highlighted in the three key areas of the grant application including: 1) significance section; 2) the abstract and project summary section; and in a section which describes the innovation and approach.

### **d. Innovation**

“Innovation is the application of better solutions that meet new requirements, unarticulated needs, or existing market needs.” In other words, innovation is defined as a new and substantive departure from the *status quo*, which opens new horizons that would otherwise



be unattainable [8]. By this definition, innovation can be technical or conceptual. To diplomatically state the innovation in a grant application, three components should be carefully considered and presented: (1) description and clarification of the *status quo* through citations, (2) explicit statement of innovation in the proposed research, and (3) description of the new research horizons, preferably relevant to the funding agency's mission, that will be attainable through the innovation in this project.

#### **e. Approach**

The approach section should contain a brief introduction, preliminary results, detailed research design, and expected outcomes, and may contain literature review and citations, as needed. The introduction and preliminary results are used to provide justification and feasibility of each aim and task. Since the approach section is often the lengthiest section of the proposal, it is critical to keep it (1) easy-to-read, (2) concise, and (3) attractive. There are two components that should not be underestimated in writing the approach section: (1) research design details, which are often supported by statistical analysis on preliminary data and power and sample size calculations; and (2) thoughtful description of potential problems and alternative approaches. Both of these components are to support the feasibility of the research project. The essence of research is that it may not always lead to expected outcomes. Funding agencies and institutions are well aware of this. However, their goal is to fund the grant proposals with the highest likelihood to succeed. Therefore, it is the grant writers' task to provide evidence as effectively and clearly as possible, often in terms of (1) well designed studies, (2) preliminary results, (3) appropriate statistical analyses, and (4) potential problems with alternative solutions. Such well thought out and carefully constructed research proposals have a high likelihood of success and can handle potential problems by taking predefined alternative routes. It is thus useful to ask

several colleagues with experience in grant application to read the proposal and prospectively think about questions reviewers may ask and answer them explicitly at the end of the approach section. We note that potential problems discussed at the end of the approach section should not have a high probability of occurrence; otherwise, they should be considered more seriously in the study design.

#### **f. Budget and personnel**

The budget should be designed based on the needs of the project and the funding agency's policies and instructions. It often includes personnel, equipment, supplies, patient care, animal care, travel, and publication costs, each of which should be justified for the particular project through a written justification. The suitability of the personnel of the research team is often an important consideration in assessing the likelihood of successfully executing the research strategy. It is important to have personnel with all of the necessary experience and skills but undesired to have redundancy in skills and overlap in tasks. Personal statements clearly describing each co-investigator or key personnel's expertise and role in the project are a necessity. Letters of commitment from collaborators should be detailed and explicitly describe their expertise and role in the project and the service they commit to provide for the successful completion of the proposed research project.

#### **g. Environment and resources**

The location or environment where the proposed research is planned to be performed, the available resources (both shared and core facilities), and the proximity and extent of access to those resources directly impact the success of a project. Therefore they are important review criteria. Again, it is the grant writer's responsibility to provide such information in a concise and easily understandable format. The facilities section may describe laboratory and office space,

animal and clinical equipment, and computer resources. This information is often accompanied with institutional commitment regarding space, equipment, protected research time, and administrative support and personnel, as well as career development opportunities and support including start-up, travel, and general funds. Intellectual resources and collaborations are other subjects to be discussed in a grant proposal. In addition to the resources and facilities, there are often critical considerations about human subjects [14], vertebrate animals [15,16], and institutional review board activities that need to be carefully addressed in a proposal.

### **3. Some specific notes on grant mechanisms**

#### **a. Small pilot grants**

These grant mechanisms are mainly designed to support early stage projects with the main purpose of collecting preliminary data for a large project. Therefore, a small pilot grant is mainly designed to collect the pilot data, analyze the data, and provide the proof-of-concept for the hypotheses and specific aims towards the long-term objective. The overall objective, level of innovation, and the originality of the proposal are thus more important in these types of grants and should be emphasized in the grant application. As a consequence of the smaller funding, pilot projects should be small, focused in scope, and should be appropriately designed for the duration of funding. Intramural funds (departmental, institutional, society and foundation funds) are usually excellent sources for these types of grants but they are also available from national and international institutes and societies [2, 5].

#### **b. Research grants**

The standard research grants, which often provide moderate amount of funding for 3-5 years, require a substantial amount of preliminary data that establish the feasibility of the specific

aims. Without such data, it is unlikely to be funded under these mechanisms. All the review criteria, including significance, innovation, investigator, approach, and environment, are seriously considered here. Mechanisms such as program project grants or cooperative agreements have been designed to support bigger multi-investigator or multi-institution studies including national and international projects, and clinical trials. [2].

### **c. Training, education, and career development grants**

These types of grants are mainly for young or junior researchers in their early stages of research career. The long-term goal in these types of grants can be something like “to develop an independent research career in ...” followed by a scientific step towards this goal. Again it includes the rationale, specific aims, and expected outcomes. The inclusion of a paragraph describing the candidate’s and the mentors’ credentials is an important part of these types of grants. Scientific and technical merit, potential of the candidate, quality of the training plan, quality of the mentorship, research environment, and institutional commitment are all taken seriously. Therefore, they should be explicitly and carefully addressed in the application. Budget should be carefully designed based on the grant mechanism instructions.

## **4. The review process**

Oftentimes, the funding agency or institution provides review criteria [17-21]. It is extraordinarily beneficial to go through these criteria before start writing a grant. Preparing the grant application in such a way that the reviewers can easily find the information that they are looking to evaluate is helpful. For example, if significance and innovation are two important review criteria, underlined and highlighted statements in the form of “this project is significant because...” or “the innovation in this project is...” can communicate it effectively with the

reviewers. To simplify the review process for the reviewers' better and easier understanding of the grant proposal, it is recommended to avoid dense writing, complex words or acronyms, jargon, and complex illustrations, and instead use descriptive headlines, simple sentences, and purposeful illustrations [12, 13]. **Table I** shows some of the most common review criteria and the corresponding questions that the reviewers should be able to answer. Ideally, the grant application should help reviewers easily answer these questions.

In support of the significance, competitiveness, and feasibility of the project, it is recommended to explicitly explain to the reviewers the main reason that the investigators are well-suited and their environment is unique for the proposed project. In fact, if the review panel find convincing positive answers to the following four essential questions, they are more likely to support the project: 1) what particular skills and expertise do the investigator(s) bring to the project?; 2) are the investigators competitive nationally and internationally?; 3) in case of a career development or training grant, what particular intellectual skills will the grantee or trainee bring in to the field of research; and 4) will they be able to bring unique significant expertise into the community?

## **5. Conclusion**

In summary, grant application preparation is a skill that is complementary to conducting high quality and scientifically sound research to foster in an area of innovation and investigation. The use of online resources and the information provided by funding institutions and peers is valuable. As various resources show, the elements of grant writing involve clear statements about the significance, rationale, and innovation in the proposed research. In addition, a detailed

description of a research plan that builds upon an innovative idea which addresses a critical need and fills a gap in knowledge or technology is essential.

It is crucial (1) to convey your enthusiasm and communicate with your reviewers through illustrations and (2) to avoid common mistakes such as flawed project design, unfocused hypotheses or specific aims, lack of significance or innovation, and an overly ambitious project design [22]. It is also critical to provide explicit information for the reviewers' to be able to easily address the review criteria. This includes the description of the particular experience and expertise that the investigators bring into the field and the unique environment that is available to them to successfully conduct the project and furnish the specific aims.

## References

### Funding sources and mechanisms:

- [1] Government agencies that provide grants: <http://www.grants.gov/web/grants/applicants/applicant-resources/agencies-providing-grants.html>
- [2] NIH types of grant programs: [http://grants.nih.gov/grants/funding/funding\\_program.htm](http://grants.nih.gov/grants/funding/funding_program.htm)
- [3] ScanGrants: A public service list of grants and other funding: <http://www.scangrants.com/category/pediatrics.aspx>
- [4] Where to search for funding? <http://sciencecareers.sciencemag.org/funding>
- [5] Society of Pediatric Radiology education, pilot, and seed funds: <http://www.pedrad.org/Research/SPRResearchEducationFoundation/GrantsAwards/ResearchAwards.aspx>

### Grant writing:

- [6] NIAID All about grants: tutorials and samples: <http://www.niaid.nih.gov/researchfunding/grant/pages/aag.aspx>
- [7] NINDS How to write a research project grant application? [http://www.ninds.nih.gov/funding/write\\_grant\\_doc.htm](http://www.ninds.nih.gov/funding/write_grant_doc.htm)
- [8] S.W. Russell, and D.C. Morrison, The grant application writer's workbook, <http://www.grantcentral.com/>

[9] Inouye, S. K., and Fiellin, D. A.. An evidence-based guide to writing grant proposals for clinical research. *Annals of internal medicine* 142.4 (2005): 274-282.

[10] Berg, K.M., et al. Demystifying the NIH grant application process. *Journal of general internal medicine* 22.11 (2007): 1587-1595.

[11] Horner, R. D. Demystifying the NIH grant application process: The rest of the story. *Journal of general internal medicine* 22.11 (2007): 1628-1629.

#### **Scientific writing:**

[12] J. Doumont, ed., *English Communication for Scientists*, Cambridge, MA: NPG Education, 2010: <http://www.nature.com/scitable/ebooks/english-communication-for-scientist-14053993>

[13] Plain language resources at NIH: <http://www.nih.gov/clearcommunication/plainlanguage/>

#### **Supporting material:**

[14] NIAID Checklists for Planning and Writing a Human Subjects Grant Application: <http://www.niaid.nih.gov/researchfunding/grant/checklists/pages/checkhs.aspx>

[15] NIH Preparing the vertebrate animal section (VAS): [http://grants.nih.gov/grants/olaw/VASfactsheet\\_v12.pdf](http://grants.nih.gov/grants/olaw/VASfactsheet_v12.pdf)

[16] NIH The vertebrate animal section checklist: <http://grants.nih.gov/grants/olaw/vaschecklist.pdf>

#### **Review process and criteria:**

[17] NIH Peer review process: [http://grants.nih.gov/grants/peer\\_review\\_process.htm](http://grants.nih.gov/grants/peer_review_process.htm)

[18] NIH Reviewer guidelines: [http://grants.nih.gov/grants/peer/reviewer\\_guidelines.htm](http://grants.nih.gov/grants/peer/reviewer_guidelines.htm)

[19] Center for scientific review (CSR) applicant resources: <http://public.csr.nih.gov/ApplicantResources/Pages/default.aspx>

[20] NIAID review criteria: <http://www.niaid.nih.gov/researchfunding/sop/pages/reviewcriteria.aspx>

[21] NSF review process: [http://www.nsf.gov/bfa/dias/policy/merit\\_review/](http://www.nsf.gov/bfa/dias/policy/merit_review/)

#### **Common mistakes:**

[22] NINDS Common mistakes in NIH applications: [http://www.ninds.nih.gov/funding/grantwriting\\_mistakes.htm](http://www.ninds.nih.gov/funding/grantwriting_mistakes.htm)

**Table I:** Some of the most common review criteria and their meaning in terms of questions that reviewers should be able to answer.

Significance	Does the project address a critical problem?
Innovation	Does the project involve development of significantly different concepts or methods?
Investigators	Are the investigators and collaborators well suited to carry out the project?
Approach	Is the research approach appropriate to accomplish the aims of the project?
Environment	Is the project site and environment appropriate for the success of the project?