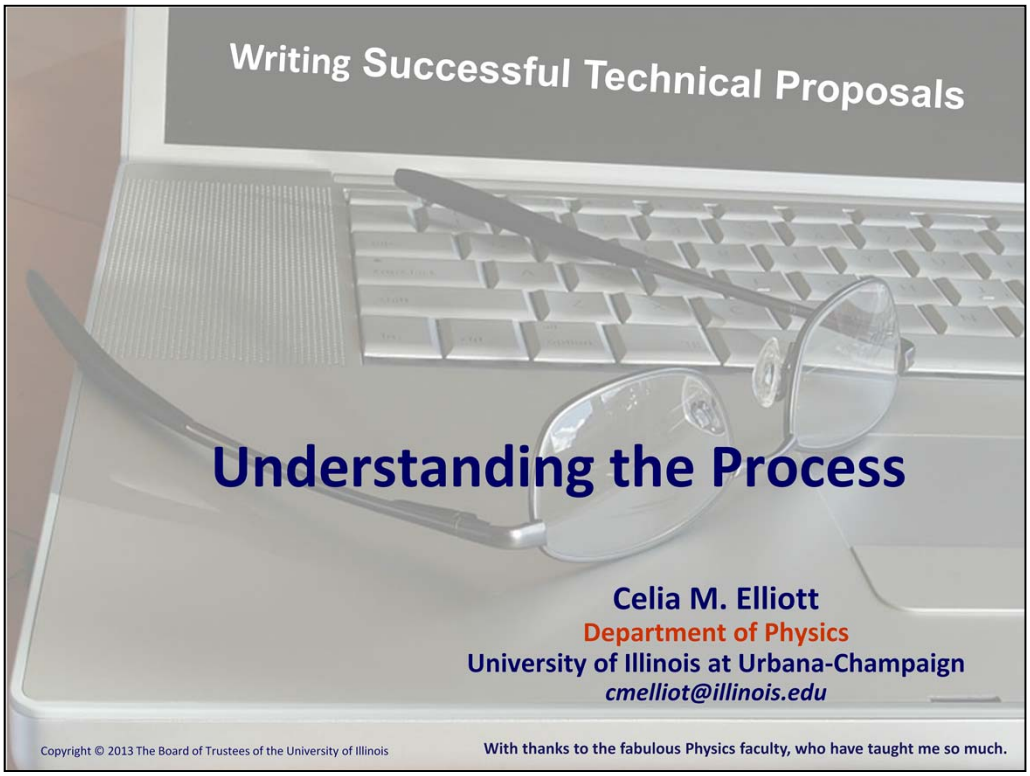


In this talk, we'll look at how scientists obtain funding to carry out their research programs.

It may come as a surprise to you, but professors at research universities get $0 from the university itself to do research—they receive salaries (for nine months a year) to teach classes, not to do research. If they want to conduct research (and get paid the other three months a year, and pay their students, and buy equipment, and go to conferences, and get their papers published, and get promoted), they have to obtain funding from external sources. In the United States, the federal government and its agencies (the National Science Foundation, the National Institutes of Health, the Department of Energy, NASA, and the Department of Defense) are the primary supporters of fundamental research in physics. So learning how to write successful proposals to federal agencies is essential if you are going to survive and prosper in academic physics.

Even if you choose a career in industry or the national labs, increasingly you will be asked to compete for research dollars within your institution.

Images in this talk were purchases from istockphoto.com, unless otherwise noted.

Okay, so what is a "proposal"?
(Hint: it is not a scientific article!)

A written description of scientific work
That has not yet been done
To be carried out by specific people
Over a specific time period
For a specific amount of money
Employing specific methods and facilities
that will, if successful,
✓✓**Create new knowledge, solve an important societal problem, train the next generation, or promote economic growth through new technology and applications**

A proposal should identify a specific research project with identifiable, measurable deliverables that will be completed in a defined amount of time for a specific dollar amount.

It is not a scientific article—it is a prospectus to a funding agency that you want to invest in your research.

A proposal is quantitative and specific. Even a high-risk, speculative project must have:

- a well-defined, scientifically motivated objective.
- a clearly detailed statement of work.
- realistic, quantifiable milestones.
- specific, measurable expected outcomes.

First steps: Find out who has the $$$$ and what they are interested in (market research)

- National Science Foundation
- National Institutes of Health
- US Department of Energy
- Defense Advanced Research Projects Agency
- Intelligence Advanced Research Projects Agency
- Air Force Office of Scientific Research
- Office of Naval Research
- Army Research Laboratory
- NASA

There will be people at your institution who know and who will help you. Find out who they are. Get to know them. Exploit them ruthlessly.

National Science Foundation—www.nsf.gov

National Institutes of Health—http://grants.nih.gov/grants/oer.htm

US Department of Energy—http://energy.gov/forresearchers.htm

Defense Advanced Research Projects Agency—http://www.darpa.gov/funding_opportunities.html

Intelligence Advanced Research Projects Agency—http://www.iarpa.gov/open_solicitations.html

Air Force Office of Scientific Research—
http://www.wpafb.af.mil/library/factsheets/factsheet.asp?id=8981

Office of Naval Research—http://www.onr.navy.mil/en/Contracts-Grants.aspx

Army Research Office—http://www.arl.army.mil/www/default.cfm?page=29

NASA—http://nspires.nasaprs.com/external/

Get acquainted with program officers. Their success is measured by the research portfolio they administer, and they want to fund productive scientists who will be successful. I've found program officers to be very helpful and candid when I've asked them questions.

The proposal process begins when the funder identifies a goal

1. Identifies a need within its mission
2. Allocates finite resources to meet goal
3. Assigns responsibility for the program to a specific person, the "program officer"
4. Creates and issues a "request for proposals" (RFP)—a document that describes the program, resources, and rules for submitting a proposal

To be successful, you must know and consider all four things when preparing your proposal

The RFP establishes the "rules" for submitting a proposal and getting an award.

READ the RFP! ADHERE TO IT WITLESSLY!

The RFP is called different things by different agencies: Program announcement (NSF); BAA [broad agency announcement] (DoD); Grant solicitation notices (DoE); NRA [NASA research announcement] (NASA); Discretionary grant applications (DoEd).

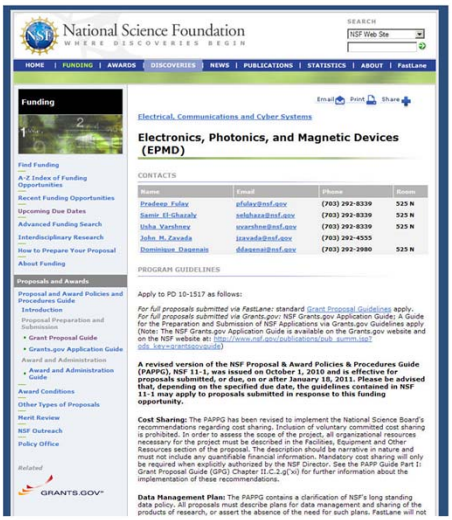
"**Eligibility**" determines (1) the type of organization that may submit (foreign or domestic; for-profit or not-for-profit; educational level; limits on the number of proposals that may be submitted by one organization), and (2) requirements for scientific personnel (minimum education; citizenship; security clearances; limits on the number of proposals a PI may be involved in).

Budget: Maximum support ($$$ per year) and maximum duration of the project will usually be specified—important boundary conditions—as well as what costs are allowed, requirements for matching or "cost-sharing" funds that the proposer must commit to the project, auditing requirements, and preparation instructions for a budget justification if required.

Deadline: Is there a "hard" deadline or a "target date"? Is the deadline "submitted by" or "received by"? Allow time to obtain required signatures and authorizations, certifications, price quotations, letters of intent or collaboration, details of subcontracts. ($t = 3H + \varepsilon$)!

Constraints: The RFP usually specifies specific page limits (for the entire proposal package as well as for individual sections of the proposal, minimum font and margin sizes, page numbering protocols, how sections are to be ordered, and how figures, tables, and graphs are to be included. READ AND OBEY!

Use the RFP for "market" research



SYNOPSIS: The Electronics, Photonics, and Magnetic Devices (**EPMD**) program seeks to improve the fundamental understanding of devices and components based on the principles of micro- and nanoelectronics, photonics, magnetics... The program enables discovery and innovation advancing the frontiers of nanoelectronics, spin electronics, molecular and organic electronics, bioelectronics... EPMD supports related topics in quantum engineering and novel electromagnetic materials-based high frequency device solutions, radio frequency (RF) integrated circuits, and reconfigurable antennas... The program supports cooperative efforts with the semiconductor industry... EPMD additionally emphasizes emerging areas of diagnostic, wearable and implantable devices...with nanoscale precision through new approaches to extreme ultraviolet metrology.

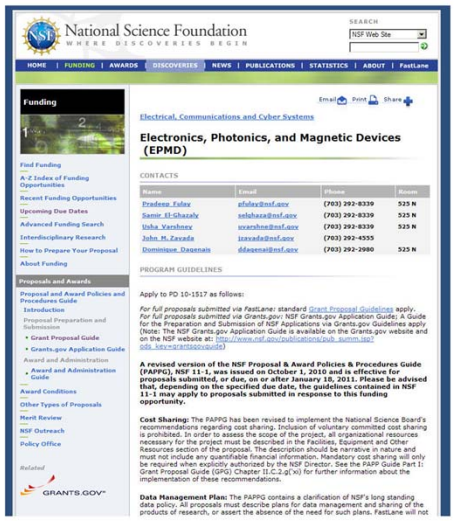
http://www.nsf.gov

Here is an example of a program announcement for NSF.

The announcement specifies contact information for cognizant staff, deviations from the standard grant proposal guidelines, and a detailed description of the types of projects the program is seeking to fund. (market research!)

Practically all funding agencies provide such details for each of their programs or calls for proposals.

Use the RFP to structure your proposal and make your pitch



SYNOPSIS: The Electronics, Photonics, and Magnetic Devices (**EPMD**) program **seeks to improve the fundamental understanding of devices and components** based on the principles of micro- and nanoelectronics, photonics, magnetics... The program enables discovery and innovation **advancing the frontiers of nanoelectronics**, spin electronics, molecular and organic electronics, bioelectronics... EPMD supports related topics in quantum engineering and novel electromagnetic materials-based high frequency device solutions, radio frequency (RF) integrated circuits, and **reconfigurable antennas**... The program supports cooperative efforts with the semiconductor industry... EPMD additionally **emphasizes emerging areas of diagnostic, wearable and implantable devices**...with nanoscale precision through new approaches to **extreme ultraviolet metrology**.

http://www.nsf.gov

Read the RFP carefully on two dimensions:

1) Proposal preparation instructions—mandatory information that must be submitted; deviations from standard instructions; deadlines.
2) From a marketing standpoint—does your project fit within the framework of the program objectives?

Make a check list of all required information:

Mandatory sections of the whole proposal.

Information to be included in the technical description.

Qualifications of the scientific personnel (biosketches).

Budget requirements.

Facilities and equipment to be used in the project.

Other support for the project/personnel.

Authorizations, certifications, signatures.

Familiarize yourself with page limits and formatting requirements.

Organize your proposal so that the information is presented in the same order that it is called for in the RFP. Use the same subject headings and numbering system.

The first cut for submitted proposals is an administrative check

Clerical review comes first

- ☑ Is the proposal complete?
- ☑ Was it submitted by the deadline?
- ☑ Does it conform to the RFP's preparation instructions?

Then the program officer (usually a generalist) looks at the science from 30,000 feet

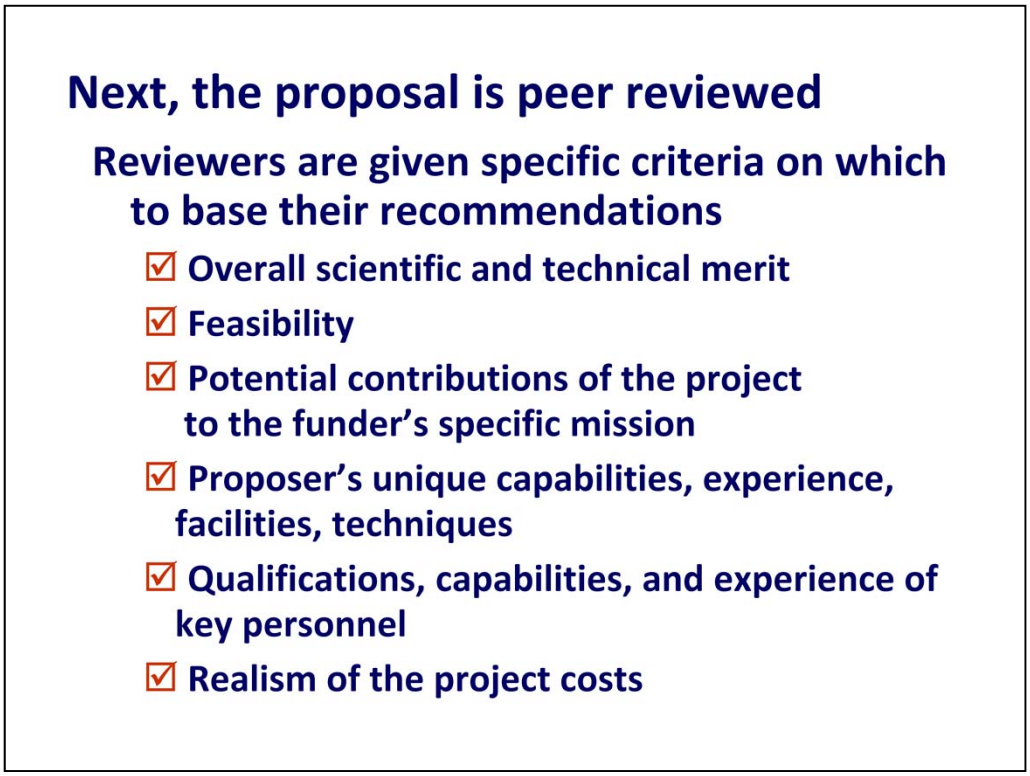
- ☑ Does the project fall within the program guidelines?
- ☑ Will it contribute to the agency's mission?
- ☑ Is it scientifically sound?

Proposals that fail the administrative check will probably be returned without review. You ***may*** get a call from the program officer allowing you to make corrections—particularly if you've submitted well before the deadline—but don't count on it.

If a program officer decides that you've submitted to the wrong program and another division might be more appropriate to review your proposal, he or she ***may*** elect to forward the proposal, but again, don't count on it. **It is the PI's responsibility to submit to the "right" program.**

Talk to the program officer before you submit—describe the project and ask if it would be of interest to that division. Program officers are usually very candid and will give you good advice if you ask.

NSF's motto: "Ask early. Ask often." Make it your own.



TIP: The RFP will often specifically state what criteria the reviewers will be asked to use in evaluating a proposal. Make a list of those criteria, and make sure you address each one in your project narrative.

Reviewers provide written evaluations and confidential recommendations.

Funding agency rank-orders the proposals and selects the highest-rated projects for funding.

The program officer works down the list, funding projects until he runs out of money.

THUS, your objective in writing the proposal is to get it high enough in the stack of meritorious proposals that the program officer gets to it before he runs out of money.

There is ***NO*** advantage to submitting a "cheaper" project (provided your budget is realistic and less than the maximum specified in the RFP).

A project might receive partial funding, which usually requires a revised work statement.

Recognize reviewer realities

- They're experts, they're busy, and they have a lot of other things competing for their attention
- They read proposals under less-than-ideal conditions
- They'll print out your proposal with the beautiful color figures on their cheap B&W printer to read on the plane
- They are ***looking*** for mistakes, omissions, objections
- They're probably reading several proposals on the same topic—how will yours compare?

Understand WHEN and HOW proposals are reviewed.

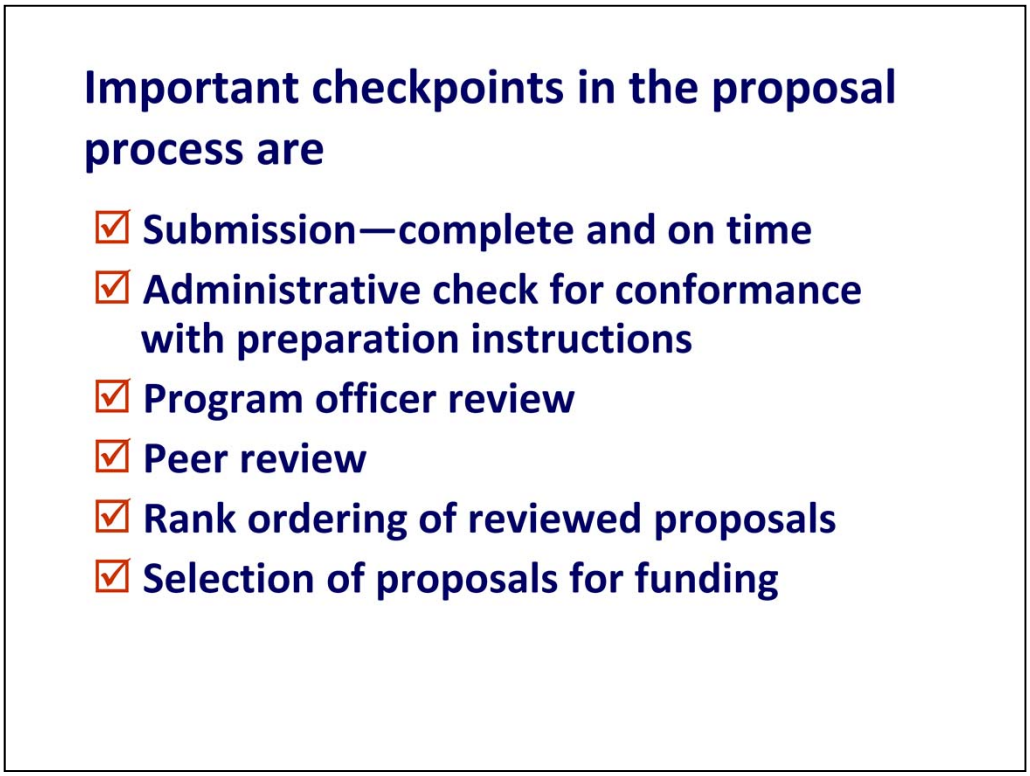
Reviewers read them when they're jet-lagged, when they're falling asleep, when they've already read fifteen similar proposals. They may read only the project summary or only the budget justification. Or they may look only at the figures.

TIP: Print your proposal on a black & white printer and look at the figures and captions. How is the reviewer going to know which is the crucial "red" line?

TIP 2: Don't put critical information in red or green in your figures. (Somewhere between 12 percent and 16 percent of white males are red/green colorblind. Who are the experts likely to be reviewing your proposal?) To see what your figures look like to someone who is colorblind (and to see what information is lost), go to http://www.colblindor.com/coblis-color-blindness-simulator/.

Reviews are often done by panels, and only one or two members of the panel will likely have read your proposal in any detail. Some may have read only the project summary and the budget. Some may have glanced at only the title page and scanned the figures. But all members of the panel have equal votes.

A reviewer should have general knowledge of your field but may not be acquainted with very technical details. Be sure even a non-expert reviewer can understand what you're going to do, how you're going to do it, and why it's important. Extract the *meaning* from the technical details.



A proposal may be eliminated from further consideration at any of these checkpoints, each of which has different criteria for a "pass."

Be sure your proposal can successfully make it past every checkpoint.

Before you pick up a pencil, answer four strategic questions...

1. ***What*** **is the goal of this project?**
2. ***Why*** **is it important?**
3. ***What*** **resources are needed?**
4. ***How*** **does this project further the objectives of the *funder*?**

Use no jargon—none!

What is the goal?
- What hypothesis are you going to test?
- What question(s) are you trying to answer?

Why is it important?
- What important questions will it answer?
- How will it stimulate future progress in the field?
- What problem will it solve?
- What useful applications might it enable?

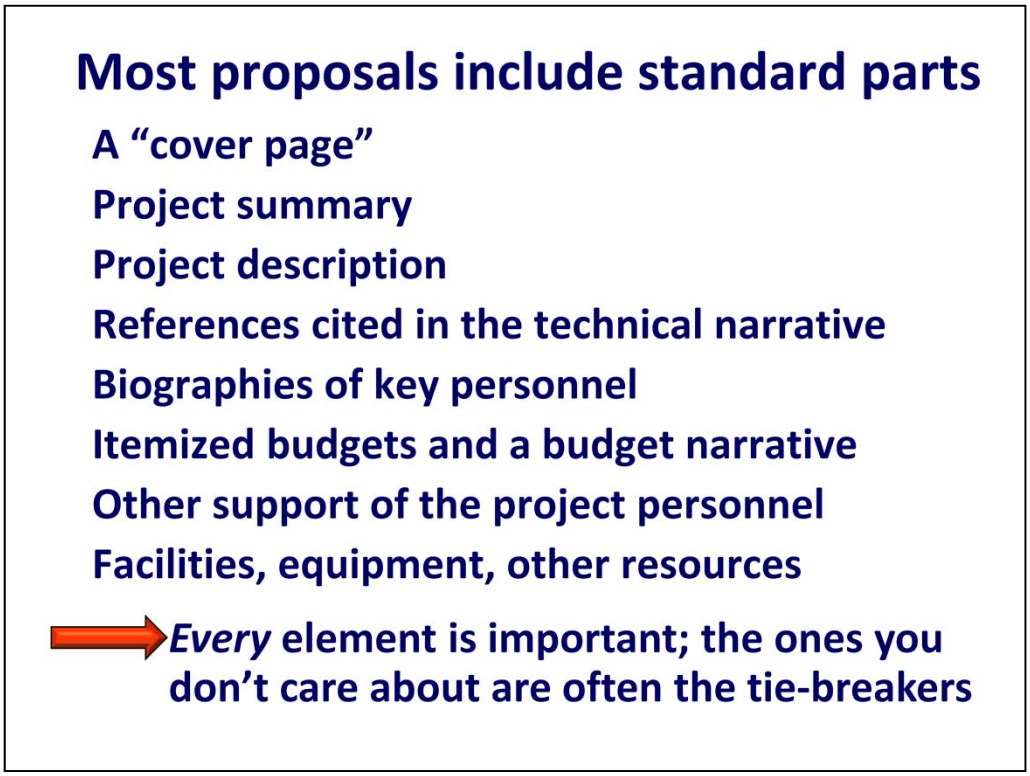
What resources are needed?
- What do you need to buy? (time as well as $$)

How is investing in your project going to further the mission of the ***funder***?
- Why should a Congressman care?

Use a journalistic writing style—who, what, when, why, how—and simple, straightforward English (no engineerspeak—q.v. http://www.youtube.com/watch?v=QtnmALC2tCs).

Write down the answers to these four questions. Think about them—write and *re*write your answers until four clear, direct, and persuasive sentences, using absolutely no jargon.

This exercise will help you to focus your thinking and to write a tighter proposal.

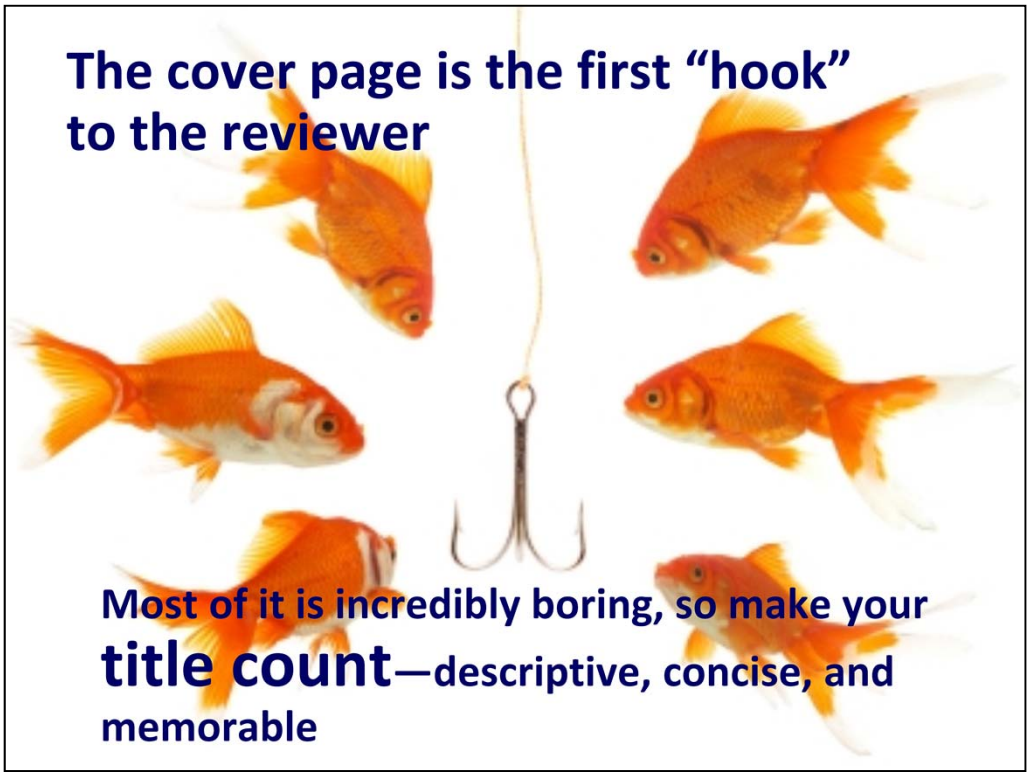


A proposal is more than just the technical description, and ***every element*** is important.

The tie-breakers are often the sections that scientists ignore—the title, the project summary, the bios, the facilities and equipment descriptions, and the budget justification.

Agencies receive far more proposals than they can possibly fund. If a panel has to decide which 3 proposals it's going to rank as "must fund" out of 25, it usually takes the most meritorious from a scientific standpoint and then ranks them based on the other components of the proposal.

Decisions are made on the margins.



A reviewer will often form a first impression of a proposal based on what's on the cover page:

The information conveyed in the title.
The reputation of the PI and co-PIs.
The total budget requested.

The title is the first "hook" to the reviewer. Effective titles are ***concise***, *descriptive* and *memorable.*

- Accurately convey the content and innovative features of the project.
- Frontload the title; put key words *first;* eschew introductory fluff.
- Limit title to a maximum of 12 words—shorter is even better—the reviewer won't remember it if it's longer than that.

Think long and hard about putting colons in titles; if you need a colon, your title is probably too long to be memorable and too unfocused to be exciting.

Avoid unfamiliar acronyms, abbreviations, or symbols in the title. The title should be meaningful to a scientifically literate person who is not necessarily an expert in your field.

A lot of the information required on the cover page (the institution's DUNS number, the CAGE code, the name and title of the institutional representative authorized to contractually obligate your organization) will be unknown to you. Give yourself time to find it out. ($t = 3H + \varepsilon$!)

The project summary is the first thing that most reviewers read

Write it for a generalist

Remember those four sentences you wrote? Use them now

Write the project summary last, so it reflects the entire project

The summary may be posted publicly

Some agencies have very specific rules—obey!

The project summary will be the first thing* that most reviewers read, and it may be the ***only*** part of the proposal that some panel members (who all have equal votes) read. Make it memorable and make every word count. ***Do not*** just reproduce the first few paragraphs of the introduction to the technical section and call it "good enough."

In general, the project summary should be written for a scientifically literate lay person, not an expert in your field. Some agencies ask you to submit both a technical abstract and a "general public" abstract of your project.

Write the project summary last to make sure it reflects the entire proposal, as it may have evolved during the writing process.

Be aware that funding agencies often post summaries publicly.

- Do not put confidential, proprietary information in the summary.
- Do not put anything in the summary that cannot be rendered in simple text (no figures, tables, or equations).
- The summary should "stand alone"; no references.

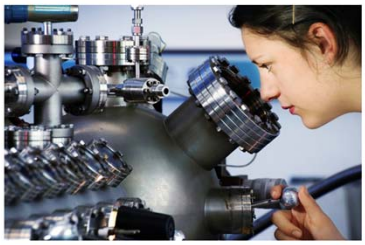
Some agencies have more specific instructions for the project summary—word limits, no first person, intellectual content—make sure you comply with them.

*You never get a second chance to make a good first impression.—Mom

The project description describes the science

Provide all the parts you'd include in a scientific paper (and some you wouldn't):

- **Introduction**
- **Review of the literature**
- **Proposed research**
- **Expected results**
- **Broader impacts**
- **Results of prior support**



The **introduction** provides a broader context for your research. This section should show the funding agency that the research you propose fits within its mission and that it's important.

The **literature review** should demonstrate that you understand the essential scientific issues associated with your proposal, that you are familiar with what has already been done and approaches that have been tried, and that you can sensibly predict likely obstacles. It should also highlight your previous work and what you've contributed to the field (predicts success).

The **research plan** should explicitly state your goal (what hypothesis you're going to test) and your objectives (what specific activities you are going to undertake to reach your goal). It should describe your apparatus and methods in sufficient detail that a reviewer can understand what you're proposing to do and exactly how you're going to go about it. It should provide information on who is going to work on the project and what their tasks will be. It should provide a timeline for the project, with specific milestones.

Make sure each procedural step is reasonable, that you convey your understanding of the potential technical difficulties, and that you have carefully thought out alternatives if your initial approach fails.

Break up the technical narrative into well-defined sections (and subsections) and use meaningful, content-rich headings to guide the reader along your arguments.

The technical narrative should discuss what you expect the results to be and explain how you're going to measure them, how you'll know when you're "done," and what you think they'll mean. **An analysis of expected results is the part that's most often missing from the technical narrative.**

CVs of key personnel who will work on the project are required

- Do not include any information that is not specifically requested
- Select publications and activities that are most closely related to the proposed project
- Conform to all page limits and formatting requirements
- Don't pad your personnel list

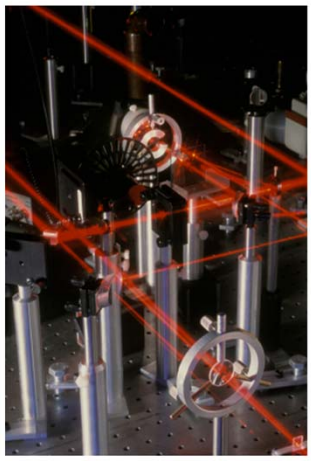
Most funding agencies have very strict rules about what may and may not be included in biosketches, as well as for whom they must be provided, and they are merciless about enforcing the rules.

Develop a template based on instructions in the RFP, including prescribed formatting and fonts, and provide it to each person on your team. You can waste an enormous amount of time trying to get biosketches into compliance—time that you could much better spend on other things—and it just looks unprofessional to have six wildly different-looking bios.

Don't put anybody on the proposal who is not clearly making a significant contribution to the project. Reviewers detest padding and "window dressing."

The facilities section should highlight your (unique) capabilities

- Emphasize special facilities and equipment
- Highlight your successes in prior work
- Show leveraging of existing infrastructure



Provide a narrative description of laboratory, clinical, animal, equipment, computers, shared facilities, and any other resources that you will employ in carrying out the project.

Emphasize special equipment or facilities that make your team uniquely able to carry out the proposed research.

If you have existing equipment or facilities that will be used in the project, explicitly state that the funding agency's support of your proposal will be highly leveraged by your institution's prior investment in research infrastructure. (competitive advantage)

Use the "Heilmeier catechism" to evaluate your proposal

- What are you trying to do?
- How is it done now, and what are the limits of current practice?
- What's new in your approach, and why do you think it will work?
- Who cares?
- If you're successful, what difference will it make?
- What are the risks and payoffs?
- How much will it cost?
- How long will it take?
- What are the midterms and final exams to evaluate its success?

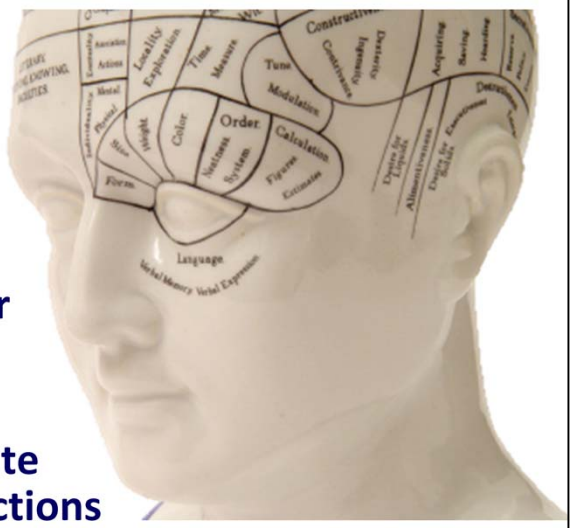
Dr. George H. Heilmeier is an American engineer, inventor (liquid crystal display), and businessman. He led at various times in his career Bellcore, Texas Instruments, and the Defense Advanced Research Projects Agency. He served as a White House Fellow and special assistant to the U.S. Secretary of Defense. He is a member of the National Academy of Engineering and has won numerous honors and awards. He is the holder of 15 U.S. patents.

G. Heilmeier, "Some Reflections on Innovation and Invention," Founders Award Lecture, National Academy of Engineering, Washington, D.C., Sept. 1992.

The photo of Heilmeier was taken from Wikimedia Commons, http://en.wikipedia.org/wiki/File:George_H._Heilmeier.jpg.

Most proposals do not fail because of bad science—but because of

- Failure to follow directions
- Poor logical organization
- Lack of detail
- Failure to consider the funder's objectives
- Failure to anticipate reviewers' objections

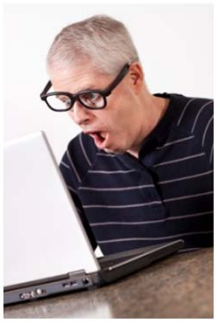


Failure to follow instructions

- Not submitted by deadline
- Exceeds page or budget limits
- Missing signatures and certifications
- Mandatory information not supplied

Remember that decisions are made on the margins. Assume that all of the proposals that you're competing with will represent solid science. It's the other elements of the proposal package—the alliance with other funder goals (education and outreach, diversity, tech transfer), the perceived qualifications of the PI and other personnel, the strength of the management plan, the planning for obstacles—that often mean whether a project is funded or not.

If your proposal fails (and some will)…



- Ask for copies of the reviewers' comments
- Find out what kinds of projects *were* funded
- Talk to the program officer about resubmitting
- Investigate other funding agencies
- Rewrite it and submit it again, or—
- Recognize that there is no "market" for the project, at least for now, with that agency, and move on
- Don't give up!

Take a deep breath, put your ego aside, and consider the reviewers' comments objectively and constructively. If they didn't understand what you want to do and why it's important, perhaps they really aren't idiots; perhaps you didn't explain it well enough.

Talk to the program officer. They are usually very candid and can give you good advice about resubmitting.

To recap:

Do your market research

Ask early and ask often

Enlist people to help you

Pay attention to your title and your project summary—they're really, really important

Emphasize what the "buyer" gets

Have pity on your reviewers; make their job easy

You may not win the first time—keep trying!

Questions? cmelliot@illinois.edu

NOTES: