



How to Get Started in Research with Undergraduates in the Natural Sciences

Dr. Mel Druelinger - Colorado State University – Pueblo

mel.druelinger@csupueblo.edu

Professor of Chemistry

Dr. Mike Castellani - Marshall University

castella@marshall.edu

Professor of Chemistry

18th CUR Biennial National Conference

Arlington, VA

July 2, 2018



How to Get Started in Research with Undergraduates in the Natural Sciences

Abstract

The process from negotiating a start-up package to navigating the process of interacting with the administration and recruiting and managing students is something few PUI faculty are trained for. This workshop covers the following topics: **project selection**, **student selection and management**, **benefits and risks of collaboration**, **working/negotiating with your chair and dean for institutional support**, **understanding institutional culture**, and the **basics of proposal writing**.

This interactive session will give pre-tenured faculty the opportunity to learn from and discuss with experienced faculty how to establish and manage a research program with undergraduate students, primarily in the natural sciences.



How to Get Started in Research with Undergraduates in the Natural Sciences

Outline

1. **What is UG research?**
2. **Selection of research projects**
3. **Selection of students**
4. **Mentoring undergraduates**
5. **Group structure**
6. **Collaborations – benefits and pitfalls**
7. **Role and importance of institutional support**
8. **Grantsmanship and proposals - Fundamentals of proposal writing**

What is Undergraduate Research?

Undergraduate research is an investigation or inquiry conducted by an undergraduate (**in collaboration with a faculty mentor**) that makes an original intellectual or creative contribution to the discipline

- Assumes faculty members subscribe to the “teacher-scholar model”
- **Promotes the concept that both students and faculty members are partners and are committed to and have a shared interest in the research experience and its success**
- Educational benefits gained by students
- **Faculty receive professional recognition**
- The research community benefits from wider scientific contributions – and society
- **Institutional recognition and prestige**



So....Why should you engage in UG research?

- **Expectations - department, college and discipline**
- **Keeps you connected with other scientists and keeps you up to date on advances and literature**
- **Keeps you intellectually vital and engaged**
- **Enhances student learning and outcomes**
- **It's enjoyable and stimulating**

Characteristics of Undergraduate Research



Mentorship

Originality

- ❖ Should be novel - entirely or partially
- ❖ Student should make a significant, original, and meaningful contribution

Acceptability

Uses approaches, methodologies, and techniques that are appropriate and recognized in the discipline

Dissemination

- ❖ A final, tangible product for which both the process and results are peer-reviewed, critiqued, juried, judged, etc. (ideally a journal publication)



How to Get Started in Research with Undergraduates in the Natural Sciences

Selection of Projects for Undergraduate Research

- Pursue projects that are **interesting** and **doable** within the context of your environment (students – ability and number, resources, time, instrumentation, etc.)
- **Choose a project that allows you to start immediately**
- Pursue projects which are interesting to you and others! Take advantage of your expertise but don't get mired in the past – be willing to reach out and extend. Within the context of your expertise, demonstrate your intellectual independence (from former advisors)
- **Scientific merit is essential for funding and publication**
- Decide whether to choose smaller more focused projects for each student or larger projects for which students may do a piece (pros and cons)



How to Get Started in Research with Undergraduates in the Natural Sciences

Selection of Projects for Undergraduate Research

- Pursue projects that can be conducted during the academic year as well as in the summer (continuity)
- Choose projects which can be pursued by students at various levels (freshmen- seniors, HS -?)
- Plan for problems – they will come up – e.g. dead end steps, instrument failures – always have a Plan B!
- Choose projects, especially initially, in which the likelihood of success is high – you need those results!
- Choose projects in which you can be a good mentor
- Give appropriate safety instruction – be wary of hazardous projects



How to Get Started in Research with Undergraduates in the Natural Sciences

Choosing a Project

- **Be critical – is this fundable and publishable?**
- **Is this an idea whose time has come? Or gone?**
- **Pursue multiple lines of investigation simultaneously**
- **Divide work so students function in series *and* in parallel**
- **Find your niche – but don't get too comfortable!**
- **Be receptive to serendipity**

How to Get Started in Research with Undergraduates in the Natural Sciences



Pursue a project that:

Enables you to start immediately after beginning your faculty position

★ Continuity of research and publication important for reviewers

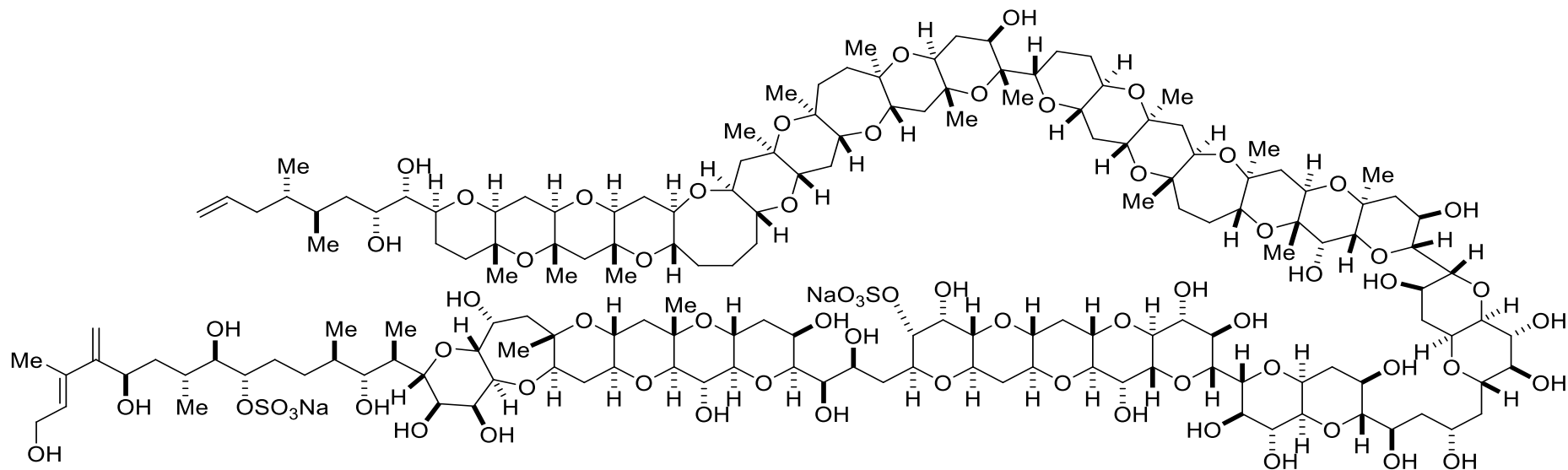
★ Integration of research and education essential to developing your professional career

Begin pursuing funding opportunities before you arrive on campus.

Choosing Projects

What about total synthesis of natural products?

It depends on the target...



Maitotoxin (MTX)

Probably not !



How to Get Started in Research with Undergraduates in the Natural Sciences

STUDENTS AND THEIR SELECTION

- They need not have the highest GPA
- They should be curious, inquisitive, dedicated and diligent
- Be able to work independently and in collaboration with others
- They need to be able to work carefully
- Ask your colleagues for student recommendations



How to Get Started in Research with Undergraduates in the Natural Sciences

Selecting Students

- **Recruit** deliberately, but be *choosy*
- Be *enthusiastic*, but honest about *expectations*
- Be *patient*, but know when to *cut them loose*



How to Get Started in Research with Undergraduates in the Natural Sciences

MENTORING UNDERGRADUATES

- They require considerable individualized attention
- **Be friendly with students but find what level of familiarity with them is appropriate for you**
- Even the brightest student can accomplish only so much
- **Give them adequate background and reading**
- Set ground rules that you intend to enforce
- **Their goals are not the same as yours**

How to Get Started in Research with Undergraduates in the Natural Sciences

MENTORING UNDERGRADUATES

- **Be patient. Don't sweat the small stuff**
- **You are now a role model**
- **Think before you speak in front of them**
- **Emphasize laboratory safety**
- **Learn how to motivate students who have little initiative**
- **Teach them to maintain good records – give examples**
- **Give encouragement on failed projects**

Above all, be accessible



How to Get Started in Research with Undergraduates in the Natural Sciences

Traits of Effective Mentors

Effective mentors often possess such qualities as:

- ***Accessibility***: An approachable attitude.
- ***Empathy***: Personal insight into what the student is experiencing.
- ***Open-mindedness***: Respect for each student's individuality and career goals.
- ***Consistency***: Routinely acting on your stated principles.
- ***Patience***: Awareness that students make mistakes and that each person matures at his or her own rate.
- ***Honesty***: Ability to communicate the hard truths about a student's performance.

Adapted from *Making the Right Moves: A Practical Guide to Scientific Management for Postdocs and New Faculty*, Second Edition, Howard Hughes Medical Institute and Burroughs Wellcome Fund, 2006



How to Get Started in Research with Undergraduates in the Natural Sciences

Strategies For Effective Mentoring In Your Laboratory

- ★ **Make Everything a Learning Opportunity**
- ★ **Set Specific Goals and Measures of Accomplishment**
- ★ **Encourage Strategic Thinking and Creativity**
- ★ **Uphold Professional Standards**
- ★ **Impart Skills**
- ★ **Provide Networking Opportunities**
- ★ **Give Moral Support**

- ★ *Adapted from Making the Right Moves: A Practical Guide to Scientific Management for Postdocs and New Faculty, Second Edition, Howard Hughes Medical Institute and Burroughs Wellcome Fund, 2006*



How to Get Started in Research with Undergraduates in the Natural Sciences

Mentoring Expectations

- ★ Mentoring undergraduates is first and foremost an educational activity.
- ★ **Undergraduate research students are not graduate students!**
- ★ Mentors must accommodate to students' varying levels of preparation, skills, and abilities.
- ★ **It takes time and patience to mentor an undergraduate student.**
- ★ Interactions between an undergraduate student and his/her mentor are critical to a successful research experience.



How to Get Started in Research with Undergraduates in the Natural Sciences

Mentoring Considerations

- ★ **Expected hours in the laboratory**
- ★ **Proper notebook record-keeping**
- ★ **Care, maintenance, and use of instruments**
- ★ **Safety and research responsibility**
- ★ **Expected outcomes of research project and faculty mentor expectations**
- ★ **Expected timeline for research activities**



How to Get Started in Research with Undergraduates in the Natural Sciences

Mentoring Challenges

- ★ **Motivating a student who shows little independent initiative**
- ★ **Encouraging a student who is frustrated by a project that fails**
- ★ **Advising students of unrealistic expectations of research**
- ★ **Training a student to maintain careful records**
- ★ **Convincing a student of the importance of routine and sustained effort**

*If I had one piece of advice to give
it's that although you've been
hired for your scientific skills and
research potential, your eventual
success will depend heavily on your
ability to guide, lead,
and empower others to do their
best work.*

**—Thomas Cech, 1989 Nobel
Laureate and President, HHMI**



How to Get Started in Research with Undergraduates in the Natural Sciences

Working with Students

- **Students should do regular hours**
- **Talk with students who aren't making it**
- **Have regular group meetings and student reports. Rotate speaking assignments**
- **Require final a presentation/report**
- **Encourage conference presentations**
- **Keep their chins up!**

How to Get Started in Research with Undergraduates in the Natural Sciences

Working with Students – Nitty-gritty Checklist

- **Start with discussion before the semester, perhaps invite prospective students to group meetings**
- **Hand out ideas & references; then meet later**
- **Agree on a project before the semester**
- **Do ordering and collect schedules**
- **Have a group meeting early in the term**
- **Do training and communicate regularly**
- **Present deadlines and targets**

How to Get Started in Research with Undergraduates in the Natural Sciences

Successful Professors

- **Do research all year and do their best to get research support.**
- **Work in the lab at least part-time.**
- **Keep the group motivated**
- **Sometimes make hard decisions**
- **Have a passion for science and student success.**
- **Link research with courses to try new ideas, recruit students and begin training before research**
- **Present and publish**
- **Want the best for their students after graduation**



How to Get Started in Research with Undergraduates in the Natural Science

When Working with Students

-Remember

- **Listen to successful colleagues at similar institutions and learn from existing examples**
- **Listen to students and learn from success and mistakes**
- **Find students that match your lab personality and goals**
- **UGR really does matter for your students**



How to Get Started in Research with Undergraduates in the Natural Sciences

GROUP STRUCTURE

- **Students with a range of experience**
- **Maintain continuity with students who will work in your group during more than 1 year**
- **Appropriate groups size is necessary for**
 - **Student satisfaction and understanding**
 - **Leadership development**
 - **Research productivity**
 - **Giving you more personal time**



How to Get Started in Research with Undergraduates in the Natural Sciences

COLLABORATION -BENEFITS

- **Makes available additional methodologies, equipment, expertise**
- **Possible greater productivity per dollar**
- **Cross-fertilization of ideas may enhance chances for funding**
- **Allows you to stay abreast of a greater range of research**
- **Can serve to bring together a range of departments**
- **May lead to new innovative curricular ideas**
- **Develop student skills needed in future employment**
 - **Teamwork**
 - **Multi-disciplinary cooperation**
 - **Develop skills for communication across boundaries of traditional disciplines**



How to Get Started in Research with Undergraduates in the Natural Sciences

COLLABORATION –PITFALLS

- Structures of departments and divisions dictates budget and indirect cost allocations
- Research timescales may be different
- Faculty evaluation -Who receives credit can be important in promotion and tenure decisions
- Must demonstrate to reviewers and research community that the level of research and intellectual rigor match that of single disciplines



The Art and Necessity of Gaining Internal Support from Institutional Administrators

Key Institutional Administrators

Chair

Dean

Sponsored Program Director

Provost (VPAA)

(President)



The Art and Necessity of Gaining Internal Support from Institutional Administrators

Chair

- **Chairs are chosen by a variety of means and for a variety of reasons**
- **The Chair plays an essential and pivotal role in the administrative chain; their support is needed to proceed further up the chain (to the Dean)**
- **Chair is the key in finding and allocating resources**
- **Chair is the lead in creating a departmental environment that facilitates undergraduate research**

The Art and Necessity of Gaining Internal Support from Institutional Administrators



Why is Institutional Support Necessary?

- **Start-up costs (and continuing costs)**
- **Space allocation** **Supplies**
- **Equipment (and maintenance)**
- **Student support (AY and summer)**
- **Faculty summer support**
- **Support staff** **Travel Support**
- **Reassigned time (for research and proposal writing)**
- **Recognition of your efforts**



The Art and Necessity of Gaining Internal Support from Institutional Administrators

Problems/Issues

- **Insufficient resources to accomplish goals – research, curriculum developments, programmatic enhancements**
- **Institutions in transition – teaching → research (mindset against research – at top leadership?, with faculty?)**
- **Indirect Cost Returns – F&A policy; to PI in form of travel, equipment acquisition, supplies, student support, etc.**



The Art and Necessity of Gaining Internal Support from Institutional Administrators

Understand the Institutional Culture (essential)

- What are the expectations (teaching vs. research or are they integrated)?
- Understand the institution's mission and how UG research can enhance and support it; act constructively to change it
- Is research (scholarship) valued? Is the teacher/scholar model the norm or the exception?
- If UG research is not central to the mission, reference other successful peer institutions
- Model successful peer institutions

The answers to these questions determine whether you have a significant uphill battle to pursue your research



The Art and Necessity of Gaining Internal Support from Institutional Administrators

Interacting with Administrators

- **Convince otherwise skeptical administrators who are not already attuned to research about why supporting this will advance the institution (e.g. recruiting, retention, improved image and visibility to public, employers and grad schools)**
- **Arguing just on the basis that it's good for the student usually doesn't fly (nor does just arguing!)**
- **Use appropriate literature to support your view**
- **Encourage administrators to attend CUR Institutes – e.g. Institutionalizing UG Research and to send faculty to the CUR Proposal Writing Institute**

The Art and Necessity of Gaining Internal Support from Institutional Administrators



Interacting with Administrators

- Offer solutions whenever you present challenges or problems
- Offer Plan A and Plan B, recognizing different contextual constraints
- Present a proposal in the context of how it would address one or more of the major goals of the department, college or institution
- Encourage the thinking that UG research is not a separate activity apart from the educational experience but is an integral part of UG education

The Art and Necessity of Gaining Internal Support from Institutional Administrators

The Start-Up Package

- **Remember the ball-park figure given during your interview, and after you are offered the job, negotiate higher.**
- **Spread your start-up funds over 366 days. Your administration might be able to increase the size of your package because it is being spread over two or even three fiscal years.**
- **Start-up is not just money! Negotiate your teaching and service load.**
- **If your impressions from the Dean are different than those from the department chair, seek clarification.**
- **Within reason, ask for tenure expectations to be provided as part of your offer package.**



The Art and Necessity of Gaining Internal Support from Institutional Administrators

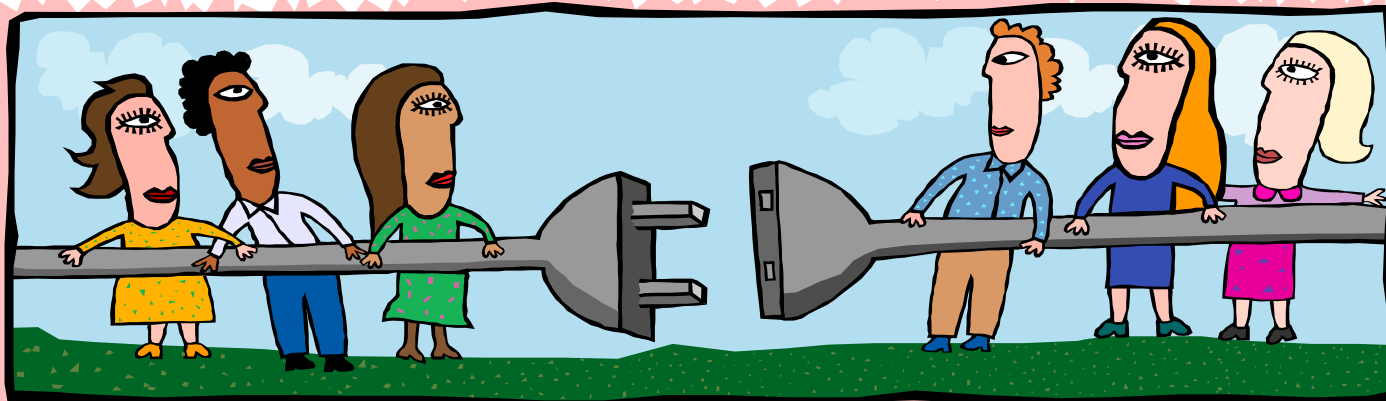
Network

- **Talk with successful colleagues (at your school and at other institutions, especially successful peer institutions); how have they achieved their success?**
- **Attend supportive professional meetings (e.g. ACS, CUR national meetings, PKAL, etc.)**
- **Don't work in a vacuum – collaborate when appropriate**
- **Collaborations – interdisciplinary or multidisciplinary; bring together faculty in new groups with common goals**

Networking is Important



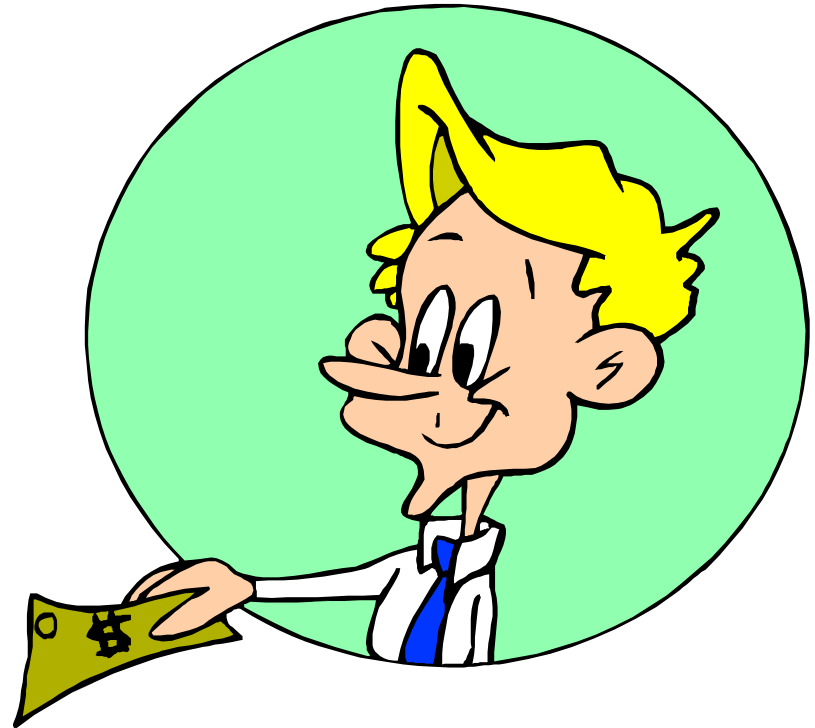
“Although humans make sounds with their mouths and occasionally look at each other, there is no solid evidence that they actually communicate with each other.”





Fundamentals of Proposal Writing

Securing Funding





Fundamentals of Proposal Writing

Why write grant proposals?

- **Most projects requires money – students, supplies, instruments, travel, etc.**
- **Develops your scholarly ideas and helps you focus - even if not funded**
- **May be expected by your department and/or university (promotion/tenure)**
- **Supports students**

THE MAZES WERE TOO EASY,
SO NOW THEY HAVE ME RUNNING
THROUGH BUREAUCRACIES AND
LOOKING FOR GRANTS.



10-10
©2007 CONEY
SPEEDBUMP.COM
THEY'RE CREATOR'S SIGN.

Pardon me, but could you tell us where the public trough is?



"Pardon me, but could you tell us where the public trough is?"



Here it is!



Fundamentals of Proposal Writing

Some Reasons Given Why Grant Proposals Aren't Written

- **Feeling that one doesn't have the time**
- **Convinced they won't be funded**
- **Aren't serious about doing research/scholarly activities**
- **Don't have adequate support or resources**
- **Unable to pursue major transformative projects**
- **Inadequate rewards for effort level**



Fundamentals of Proposal Writing

- Develop an original and excellent idea which meritorious (intellectual merit) – but doable within your context
- Investigate funding sources - (Grants office, CUR, colleagues, agency program officers, etc.)
- Write a proposal before you arrive and the AY begins
- Read and follow PA/RFP guidelines carefully
- Don't work in a vacuum – ask others to read your proposal and be critically constructive
- Include preliminary results if possible
- Avail yourself of the many resources on grant/proposal writing



Fundamentals of Proposal Writing

- Be clear and concise in all your writing
- Explain why your proposed work is important to the discipline (and society, if appropriate)
- Explain your experimental approach and how it will solve the problem
- Address possible obstacles (awareness) and how they may be circumvented (Plan B, or C)
- Credentialing – the reviewers must be convinced that you and your team (UGs) can be successful
- Convince reviewers that you have the appropriate infrastructure and institutional support to be successful



Fundamentals of Proposal Writing

- Highlight the impact of the work on undergraduates and that they (under your mentorship) can do the work
- **Understand the review process and the reviewers**
- **Work with your grants/sponsored programs office**

Bottom line

High quality science is essential -

Necessary, but not sufficient!



Fundamentals of Proposal Writing

Tips for Success (1)

- Find a funding source appropriate to your interests
- **Start with an excellent idea—not a rehash of earlier work**
- Clearly explain the significance of the work to discipline/society
- **Clearly explain the experimental work and how it will answer the question or solve the problem**
- If risky, cite alternatives to overcome problems
- **Convince reviewers that you can do it in your setting**
- Address impact on students

Be kind to reviewers – they hold your fate!



Fundamentals of Proposal Writing

Tips for Success (2)

- Review proposals that have been funded – contact PIs
- **Have others read your proposal – honestly and critically**
- Seek out successful colleagues
- **Work with your office of sponsored programs – allow time**
- Start early – give yourself enough time
- **Read the program announcement (PA, RFP)**
- Speak with a program officer
- **You will never get a grant if you don't submit a proposal!**

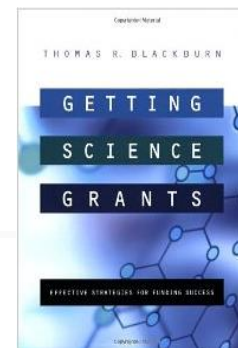


Fundamentals of Proposal Writing

Network

- **Talk with successful colleagues – ask them to read and critique your proposal (give them time)**
- **Speak with previous reviewers – know the review process**
- **Obtain copies of funded proposals (but don't copy!)**
- **Don't work in a vacuum – collaborate when appropriate**
- **Become a reviewer (volunteer via Program Officer); even new folks can be involved – but not when you are submitting!**

Gaining Funding – There is Help



- **Council on Undergraduate Research (CUR) Proposal Writing Institutes**

<http://www.cur.org/institutes/Proposal.html>

- **Workshops at Regional / National Meetings**
- **Agency Regional Grants Conferences (NSF and NIH)**
- ***Getting Science Grants: Effective Strategies for Funding Success*, Thomas R. Blackburn**



- ***Grant Application Writer's Handbook*, Liane Reif-Lehrer**



How to Get Started in Research with Undergraduates in the Natural Sciences

Grantsmanship and Proposal Writing

Remember:

You will never get a grant unless you submit a proposal!



How to Get Started in Research with Undergraduates in the Natural Sciences

CUR Books

How to Get Started in Research

How To Mentor Undergraduate Researchers (2010)

Transformative Research at Predominantly
Undergraduate Institutions



Additional Resources from the Council on Undergraduate Research (CUR)

CUR INSTITUTES:

**Beginning a Research Program in the Natural Sciences at
a Predominantly Undergraduate Institution**

Proposal Writing Institute

www.cur.org

How to Get Started in Research with Undergraduates in the Natural Sciences



Acknowledgements

- Merle Schuh – Davidson College
- Kerry Karukstis – Harvey Mudd College
- Tom Wenzel – Bates College
- Mitch Malachowski – University of San Diego
- Tom Blackburn - PRF (ret)
- Al Schoffstall – U. Colorado – Colorado Springs

Contact Information

Mel Druelinger – mel.druelinger@csupueblo.edu

Mike Castellani – castella@marshall.edu



How to Get Started in Research with Undergraduates in the Natural Sciences

Thank you!

Comments?

Questions ?



Additional Slides

Undergraduate Research Summit



<http://www.bates.edu/x50817.xml>

- **Examines issues involved in undertaking and sustaining chemistry research at predominantly undergraduate institutions (PUIs)**
- **Provides recommendations on how to enhance the amount, quality, productivity, and visibility of research at PUIs**



How to Get Started in Research with Undergraduates in the Natural Sciences

Goals for Student Involvement

- Learn how knowledge is generated – valuable to all students
- Learn to think analytically and critically and how to evaluate data and information
- Learn to be creative
- Make a real contribution to the advancement of knowledge (research productivity)

Side benefits

- Enhance resume/experience
- Learn new methods, techniques and instrumentation
- Learn to work as part of a team



How to Get Started in Research with Undergraduates in the Natural Sciences

Advantages/Benefits of Involving Students in Research For Students

- **Brings together concepts/ideas from different classes & disciplines**
- **Develops critical thinking skills**
- **Teaches problem solving skills**
- **Strengthens and reinforces communication skills (oral and written)**
- **Exposes them to a research environment**
 - **Open questions**
 - **State-of-the art equipment**
 - **Culture of academic scholarship**
- **Introduces them to a career in research**

How to Get Started in Research with Undergraduates in the Natural Sciences

Barriers to Engaging Undergraduates in Productive Research and Scholarly Activities

Faculty

- Time – teaching loads, released or reassigned time
- Resources – equipment, library, supplies, dollars
- Rewards – recognition, travel
- Mentoring experience
- Doable projects

Students

- Time – in appropriate blocks
- Commitment – intellectual
- Knowledge – appropriate skills – research, writing, performance
- Funding – for time, travel (grants, work study, credit, volunteer)
- Projects of interest
- Ability to work independently



Fundamentals of Proposal Writing

The Program Announcement

- **Read the PA carefully, then read it again!**
- **Adhere to it in detail and without exception**
- **Pay particular attention to eligibility, award size, format, page length, font size, etc.**
- **After completing your proposal, read the program announcement again!**
- **If there are questions, contact a Program Officer**



Fundamentals of Proposal Writing

Contact the Program Officer

- **Early (and often?) - they are there to help and want you to succeed. They are a very underutilized resource. E-mail, call, or visit**
- **Ask any questions you have – after carefully reading the Program Announcement**
- **Discuss your proposed project ideas – do they fit?**
- **Understand the review process (de novo or past history)**
- **Understand current funding rates, program patterns and special emphases**



Fundamentals of Proposal Writing

Know Internal Institutional Process

- **Consult with SRO (“Sponsored Research Office”) – early and often**
- **Comply with internal institutional processes – e.g. obtain necessary signatures, comply with timelines**
- **Secure sources of matching funds – e. g. department, Dean, SRO**
- **Work with the Development Office as appropriate**
- **Secure In-Kind dollars – realistically (auditable)**
- **Secure letters of support as appropriate – don’t commit others without their knowledge. Allow time to acquire**



Fundamentals of Grant Proposal Writing

Submission Considerations

- **Know deadlines – don't push them; haste and stress lead to mistakes**
- **Electronic submission may be by FastLane (NSF) or Grants.gov**
- **Don't wait until the last minute to learn the process!**
- **Don't wait until the last minute to submit – it shows (coordinate with your SRO)**



Fundamentals of Proposal Writing

If the Proposal is Rejected

- **After your initial response to the news, step back and give careful and objective consideration to the reviewer comments. The proposal really can be improved!**
- **Realize that resubmissions have a much higher success rate – assuming they are modified appropriately.**
- **Contact your Program Officer with questions – measure and temper your comments.**
- **Plan on a resubmission – informed by your experience and discussions. Don't be discouraged. No funds are awarded without effort.**