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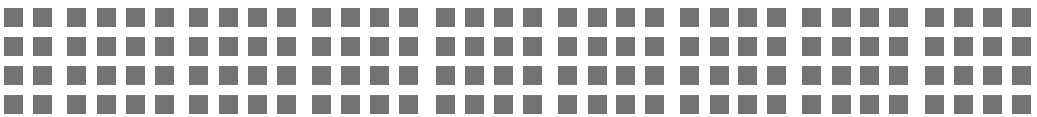
Faculty Handbook for Mentoring Undergraduates in Life Sciences Research



FACULTY HANDBOOK FOR UNDERGRADUATES MENTORING

Ann Georgi[1] and Tom Torello[1,2]
Edited by Anna Babakhanyan[1] and Margaret Lynch[1]

SCIENCES EDUCATION OFFICE
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1. Life Sciences Education Office
2. Department of Molecular and Cellular Biology

Office of Life Science Education
Harvard University
Faculty of Arts and Sciences
16 Divinity Avenue
Cambridge, MA 02138

Phone: (617) 495-9374
https://lifesciences.fas.harvard.edu/mentoring-students

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Why take an undergraduate into your research group?

Inquiry-based research is a fundamental component of the educational mission of Harvard College. Participating in basic research helps students learn how to frame appropriate scientific questions, design experiments to answer these questions and analyze and evaluate the data. Indeed, many students choose to come to Harvard, because of the opportunities to do research, and most life sciences concentrators are eager to participate in research. Some students who arrive at Harvard with an interest in studying life sciences are planning to go on to medical school; few have considered research as a viable career option. Exposure to research in the laboratory or the field is a revelation to them and opens their minds to new goals and career paths. Harvard College has a pedagogical responsibility to provide training for the next generation of scientists.

Even students who do not plan to pursue a career in research benefit from the experience of working in a laboratory. Research is the practice of science and an integral part of science education. Experience with an independent research project, either in the laboratory or in the field, provides students with a hands-on experience to engage the concepts and principles of science. Learning to design experiments that may answer a specific scientific question can change the way students think about the concepts of science. Preparing a talk about their work for the lab group or undergraduate symposium teaches them how to analyze and organize data and give a cogent presentation.

Providing research opportunities for these bright and highly motivated students also has significant benefits for the host laboratory. Some of these enthusiastic young researchers will succeed beyond expectations and many will make valid and useful contributions to the lab's research goals. Additionally, the graduate students and postdoctoral fellows who work directly with the undergraduates in the laboratory will benefit from a valuable teaching and mentoring experience.

The aim of this manual is to provide the host labs with information that may answer questions about the roles and responsibilities of faculty who host undergraduates in their labs. For additional information please attend our mentorship workshops in the Spring term.

What is your responsibility to undergraduates working in your lab?

Mentoring

Good mentoring is crucial to encouraging undergraduates in a research environment. Indeed, students report that good mentoring is a significant factor in determining their happiness and success in the lab. Even if you are not working directly with the student in the lab, it is important that either you or a senior member of the lab be actively involved with the mentoring process, ensuring that the student receives good mentoring and research training. Most labs assign a senior member of the research group (usually a post-doc or graduate student) to incoming students to direct their research training and the development of their project. This is a crucial, but very time-consuming role and the lab mentor should be aware of the time commitment before taking on a student. Before the student begins working in the lab, it makes sense for the mentor and student to establish a mutually agreed-upon schedule. This ensures that the mentor will be available when the student is in the lab to oversee their work, answer questions, teach necessary techniques, discuss results, and help plan next the experiments. Having a good lab mentor at the beginning of a student's research career can have an enormous impact on a student's decision on whether to continue doing research after college or to take a different career path.

Once the student has begun work in the lab, it is a good idea for you to meet regularly with them to assess their progress. For labs that host several undergraduates at the same time, it may be easier to schedule one weekly meeting with all of them to discuss their projects, results, future experiments and any problems that they may be having. Your direct interaction with the student sends a strong message about their value to the lab.

Other responsibilities that you and the student's lab mentor are expected to undertake include writing letters of recommendation for funding support and fellowships, advising

students on the preparation and writing of their fellowship proposals, research papers, and thesis; and contributing to assigning grades for independent research courses.

Many post-docs and graduate students will not have had any experience or training in mentoring undergraduates. Some may not have had an undergraduate research experience themselves and therefore will have little idea of what their role should be. The Sciences Education Office offers mentoring workshops and lunchtime discussions throughout the year to provide support and basic training for lab mentors.

Setting Expectations for the Student in the Lab

Because many students will not have had previous laboratory experience, it may be helpful for you to meet jointly with the student and their mentor to set out the ground rules before the student begins working in the lab. You might want to discuss such topics as:

I. How many hours per week should the student work during term time? During the summer (if relevant)?
II. How will the project topic be decided? What are the milestones and timeline for achieving project goals (given student commitment to work in the lab for 1 term or 1 year etc.)?
III. What techniques student has to learn before embarking on the research project? (It will encourage student to master a simple basic lab technique used in the lab and be successful before embarking on more complex assay optimizations).
IV. How often will you meet with the student? How often the student will meet with the direct mentor (grad student or postdoc)?
V. Will the position be volunteer/paid by PI/student fellowship support/faculty aid program/federal work-study? (See Funding section below)
VI. Is the student expected to present his/her results during the lab meetings? Providing student an opportunity to present results at the end of the project or twice during the term-time research would encourage student and provide great learning opportunity in talking about research they have conducted.

VII. And, although it may seem premature, what is the lab's policy on presenting research results at group meeting or paper authorship?

Students tend to get their information from each other and may not always realize that policies differ from lab to lab. Therefore, it is important to set out your lab's policies and procedures directly to the student to avoid misunderstandings or unrealistic expectations.

The student may have useful input to this conversation related to their course schedule, extracurricular activities, and how much time they will be able to devote to the lab. For instance, if the student is taking two lab intensive courses in the fall semester, they may realistically only be able to work in the lab a few hours per week for that term. For this reason, we recommend that you try to be somewhat flexible about the number of hours/week that you expect a student to work, especially with freshmen and sophomores whose course loads tend to be very laboratory intensive. In the long run, it is less costly and time consuming to scale back your ideal expectations than to set unreasonable conditions for the student and have them fail.

We recommend that freshmen and sophomores who are volunteering in the lab during term time, i.e. not receiving pay or credit for their work, spend no more than 6 to 10 hours/week working in the lab. However, if their course load is lighter in another term, they may be able to work more hours/week. For students who are doing lab work for credit either in a supervised laboratory course or for a senior thesis, it is reasonable to expect them to be in the lab a minimum of 15 to 20 hours/week for the term. At the beginning of the semester, students and mentors may find it helpful to discuss setting up a fairly regular schedule for coming to the lab. Obviously, it is extremely helpful for the lab mentor to know ahead of time when they should set aside time from their own experiments to work with the student. Having a regular schedule also encourages the student to keep track of how much time they are spending in the lab, which can help them avoid either becoming over committed or showing up at times when their mentor is unavailable to work with them.

There are many opportunities for Harvard students to do research abroad. Nearly all of these are summer programs geared to upperclassmen, primarily sophomores, because they require that the student have had some advanced course work and/or research experience; however, a few of these programs are open also to freshmen. Students also can find their own labs abroad for the summer and apply for fellowships to cover their costs through the Office of Career Services or the Office for International Programs (see Funding for Undergraduate Research below). Although you may have concerns about a student taking the summer away from the lab, students who participate in such experiences abroad benefit in several ways; they may gain some independence and maturity, broaden their perspectives, learn about approaches to research in other cultures and may even return with new technologies for the lab. We therefore urge faculty to be as flexible as possible and support the student's decision to take advantage of these opportunities. It may be advantageous for you to assist the student in identifying some labs abroad whose work is related to what the student is learning in your lab or you may want to suggest colleagues whose labs are likely to provide a good research and mentoring environment for the student. Rising seniors who are doing thesis work are strongly encouraged to remain in their Harvard labs for the summer.

Undergraduate Research Projects

Another key to success for undergraduate researchers in the lab (or the field) is the nature of the project. Listed below are some guidelines for creating a good undergraduate project. These guidelines are not intended to be rigid; obviously, the projects should be designed not only to take into consideration any special technical requirements and skills that the lab uses but also reflect the lab's research focus.

Characteristics of a good undergraduate research project

1. Initially, it might make sense to have the student's project be part of the post-doc or graduate student mentor's research – or be in an area in which the mentor has some experience or background – to help ensure that the mentor is qualified to teach the scientific material and techniques.

2. While students may initially gain technical expertise by assisting with experiments on the mentor's long-term research project, the expectation is that eventually the student will pursue an independent project or work independently on some aspect of the mentor's larger project. The student researcher should not be viewed merely as a research assistant for the post-doc or graduate student mentor. This is especially important for students aiming to write a thesis, but also applies to students working in the lab over the summer or for academic credit during the term. An exception to this guideline is if the lab views the undergraduate position as a paid lab assistant position and has posted a job description that clearly states that the student will not be working on an independent project. Students sometimes find this distinction fuzzy. Therefore, it is crucial that the position be described as clearly as possible in the posted job description.

For some students who do may want to do an independent research project or who do not plan to do a senior thesis, a less independent lab project is more appropriate.

Students considering a career in medicine who do not want to work in a lab for credit may seek a more clinically based research experience.

3. The project should be relatively “low-risk”; that is, the student should be able to get a result or make a contribution - however small - to the overall project in a relatively short time (over the summer, for example). Students who are doing independent research for credit or a senior thesis will be able to spend many more hours per week in the laboratory during the academic year and therefore will be expected to work on more ambitious projects. A student may begin work on a thesis project part time as early as their sophomore year although most begin thesis work in their junior year.

4. Ideally the project should utilize techniques, equipment and reagents that are already working in the lab. In some cases, exceptionally talented and ambitious students will be capable of developing new techniques and undertaking more sophisticated projects; but this ought be carefully evaluated only after the student has worked in the lab for some time. Other students may lack confidence and be discouraged by expectations that are set too high.

5. For freshmen and sophomores, who are just getting started in the lab, it is very important to consider the number of hours per week that they will be able to work during the term. Many of these students will be taking very lab intensive courses and have limited time to engage in independent lab work. We recommend that these students plan to work no more than 6 to 10 hours/week during the term; therefore, projects that have logical stopping points that can extend for days or even weeks during exam and vacation times are best. For these students, starting with a small project that might lead to a larger thesis project may be most appropriate.

6. Students are expected to do some background reading about the project to gain some understanding of the science behind the research question. Again, the goal is to encourage them, with the guidance of their lab mentor, to achieve some level of research independence, to learn how to think about experimental design and to take

some ownership of the project.

7. Finally, students are encouraged to present their research results in their lab group meetings and participate in undergraduate research symposia or poster sessions offered by the Harvard College Undergraduate Research Association (HCURA). Some of the summer fellowships require that their fellows participate in an end of program poster session or symposium. This is a good opportunity for students to learn how to design a poster or to present their research in a brief talk.

Laboratory Support

The host lab is responsible for providing adequate lab safety training for the student including the safe handling and disposal of hazardous material and radioactive reagents (if applicable) and the safe operation of laboratory equipment. Students should be familiar with all federal and Harvard University safety and ethical guidelines for work in the lab. It is also important to explain to the student any guidelines or rules that are specific for your lab. Taking the time to teach a student the required safety rules, proper lab procedures regulations and good lab citizenship at the beginning of their research career will likely help prevent problems in the future.

The NIH and NSF now require that every member of a research project funded by their agencies be trained in the rules and guidelines for academic integrity. Harvard offers Responsible Conduct of Research (RCR) training that will fulfill this requirement. Students in your lab should be strongly encouraged to participate in this training.

When Problems Arise

What happens when despite the best efforts of the student's mentor - and maybe the student - the project does not progress satisfactorily? This situation is not unusual and there are a couple of options for response, but it is important to step in fairly early on and assess the situation. This is another reason for meeting regularly with the student and their mentor.

The problem could be inherent in the project; for instance, the techniques are not working or are too sophisticated for this student. In this case, the solution might be to redesign the project or help the student develop a new one that is at a more appropriate level. However, if the problem is the result of the student's poor technique or a lack of attention to detail, it is important to discuss this with the student as soon as possible. By providing feedback and suggestions for improvement early on, you may avoid having the situation escalate to a more serious level.

Students who perform sloppy work or are careless with experiments ought to be given a second chance. Perhaps they need retraining, perhaps they have felt rushed in the lab because of pressing academic issues (exam time), or maybe they just don't get it. If there is no improvement and the problem persists, you are not obligated to allow the student to continue in your lab. Before discussing termination with the student, you may choose to alert the student's Resident Dean and Concentration Advisor, because they may know of extenuating circumstances that could be temporary and might affect your decision. If you do decide to terminate the student, giving the Resident Dean and Concentration Advisor a heads-up will help them provide support for the student going forward.

Sometimes problems arise because of communication difficulties between the student and the lab mentor. Often meeting with the two of them can resolve the problem, but sometimes cultural, linguistic or personal barriers are just too high. In this case, assigning the student to a new mentor within the lab group may solve the problem. If, however, you have the sense that the student may bear some or most of the responsibility for the lack of communication; for instance, by demonstrating a lack of respect for the mentor's time by showing up unannounced and expecting help or by refusing to abide by the lab rules despite repeated warnings, you may feel that it would be better for the student to start over in another lab.

What happens when a student has been working on a project with a mentor who is leaving to take a new position at another institution? By thinking about this early on,

you may be able to avoid this situation - for example, when matching students and mentors, you might want to consider not only their research interests but also the timing of their stay in the lab. If the unavoidable happens, however, you may be able to plan for a smooth transition. For example, the solution can be quite simple if there is someone else in the lab with the expertise to continue mentoring the student on the project or if the student is just getting started and is not heavily invested in the project. The real problems arise when the student's work is quite far along and no one else in the lab is qualified to oversee the continuation of that project, or if the mentor is taking the project when they leave. This situation rarely arises, but it can have serious ramifications for the student when it does. In a few cases students have had to abandon their thesis senior year because they were unable to continue the project unaided. In this situation, you may want to encourage the student to contact their Concentration Advisor or Undergraduate Research Advisor for advice.

What should the lab expect from the student researcher?

It is important from the beginning for students to recognize that their training will require a significant time commitment from their lab mentor and that they should demonstrate respect for this commitment by arranging to be in the lab according to a schedule agreed on in advance with the mentor. Especially when just starting out in the lab, students should avoid planning to work in the lab on nights and weekends when no one else is there to supervise them. In cases where students cannot avoid being in lab at night or on weekends, it is their responsibility to ensure that another lab member will be working in the lab at the same time. Until they are fully trained and able to work independently, students should not work in the laboratory unsupervised.

As mentioned above, students and their mentors are expected to meet with you regularly. The students should approach these meetings in a professional manner and be prepared to discuss matters pertaining to their lab work, including progress on their research, their schedule in the lab, and upcoming deadlines for proposals or written assignments.

Students are often required to write about their work for fellowship applications, final papers for research courses, and, of course, their senior theses. The interactions between students and mentors while preparing a written text can be among the most in-depth and rewarding of their research experience. However, frequently students do not engage with their faculty advisors or lab mentors early enough in the writing process to reap the benefits of this interaction. It may be helpful to encourage your student to submit drafts well in advance of the due date so that there is adequate time for you to provide feedback.

It is reasonable to expect the undergraduates who come into your lab to be "good lab citizens" and follow the tenets laid out in your first meeting. If a situation arises in which it becomes apparent that a student has treated others in the lab with disrespect, failed to clean up at the end of an experiment, used up the last of a lab

stock reagent without replenishing it or ordering more, etc., you may want to have a follow-up conversation with the student to reemphasize good lab practices and lab citizenship. It is often much better to address these issues as a positive teaching moment when they first arise rather than allowing the situation to continue and perhaps deteriorate to a point where the lab is adversely impacted and a more difficult conversation becomes necessary.

Above all, it is important for the students who come to your lab to approach their projects with genuine interest and intellectual curiosity. Regardless of the limited time that freshmen and sophomores are be able to devote to their lab work, all students should convey true intellectual engagement with their projects and the lab's research goals rather than give the impression that they are there just to fill a degree requirement or as a pre-requisite for a post-graduate program.

Students may sometimes elect to change labs. Often this decision is based on a change in the student's scientific interests; for example, they have finally decided on a concentration that is unrelated to their work in the lab. However, there also may be other reasons for leaving a lab. The student may be frustrated with the pace of progress on their project or have personal reasons for leaving. Sometimes they have realized that they are just not interested in doing research. These decisions are not made impulsively; students often think about it and seek advice from their concentration advisors, house tutors or other members of the community for several weeks before taking action. Students tend to be loyal to their labs and many have a difficult time making the decision to leave. Some students find facing the conversation with their lab mentor and PI about leaving the lab extremely difficult. You can help by being patient and understanding even if you are caught completely by surprise and are disappointed in the student's decision. You may find the conversation helpful for mentoring other students in the future.

Recruiting undergraduate researchers

There are several ways you can recruit undergraduate researchers:

- If you are teaching a course, you can meet interested students
- Students can contact you directly
- Very often, if a faculty member has an Undergraduate Research Opportunity, they are encouraged to contact the Harvard Science Education Office in order to post their opportunity on the Science Education website. Undergraduate Research Advisor advises individual students and will be able to refer relevant students to the faculty once the position is posted online.
- Science Education Office organizes an annual poster event (HUROS) in the early November, which is a great opportunity to meet with dozens of undergraduates in one day. You, your postdoc or graduate student can represent your research group. For more information about registering for the poster event check the HUROS website.

Funding for Undergraduate Research

Funding is available to provide a wage/stipend for undergraduates working in labs. Normally the host lab is responsible for covering the costs of reagents and materials for the student's project. There is little support from the Harvard College to supplement a lab's expenses for student projects.

Term time funding through Harvard

Limited term time funding is available for students who have high financial need or who are on financial aid. Freshmen and sophomores, who are just getting started in the lab are encouraged to volunteer their time while they are being trained. Juniors and seniors are more likely to work for academic credit either through a supervised research or senior thesis course. Students who have high financial need or who are on financial aid may opt to receive a stipend rather than academic credit. It is important to note that during the term students may not receive funding and academic credit for research work simultaneously.

Four primary sources of funding are available to students during the academic year:

1. Faculty may pay the student a full or part stipend directly from lab funds.
2. The lab may apply to the Faculty Aide Program (FAP) through the Student Employment Office, which pays 50% towards student's stipend.
3. The student may be eligible for the Federal Work Study Program (FWSP), which pays 70% towards student stipend and the rest is covered by the lab.
4. Students may apply to the Harvard College Research Program (HCRP), which provides an hourly salary and transportation funds (sometimes students can request funds to offset cost of the missed meals in the dining hall if they work long hours in the lab). HCRP has high funding rate during the term-time, but is still competitive. It requires 3-5 page proposal, hiring faculty letter and detailed budget.

Summer Research Funding through Harvard

A reasonable guideline for summer compensation rates is that students, who do not live locally and are not participating in one of the summer residential research fellowship programs will need about $3500 for housing and living expenses for 10 weeks in Cambridge. Students who do have local housing for the summer generally will need around $1500 to $2500 for living expenses depending on their meal plan. In some cases, students on financial aid may need more financial support because these suggested stipends, which assume full time work for 10 weeks, are unlikely to cover the student's financial aid summer earnings contribution. The goal is to provide enough financial support for students working in the lab over the summer so that they will not need to find an outside job to meet living expenses and financial aid obligations.

Below is a list of some of the major sources of support for students who are doing research at Harvard over the summer. Note that with the exception of HCRP, the fellowships assume a "full time" commitment to the lab of at least 40 hours/week for ten weeks during the summer. Students must use the Common Application for Research and Travel (CARAT) - which is available electronically from the websites of all participating funding agencies - to apply for the Harvard summer fellowships. This form is an effective bookkeeping tool that allows the funding programs to track each student's fellowship applications.

With the exception of PRISE and some of the smaller fellowships designed to supplement HCRP, students may not accept financial awards from more than one fellowship at a time. For example, a student may not simultaneously accept funding from both Herchel Smith and HCRP, however a student may accept funding from Herchel Smith and participate in the PRISE program. The purpose of this restriction is to avoid situations whereby a few students receive multiple fellowships while others receive little or no funding. In some cases, a student who has been accepted for two fellowships may accept the financial award from one and participate in some of the non-financial aspects of the other fellowship program. For example, a student who is accepted for both Herchel Smith and The Harvard Global Health Institute SURF

fellowships may receive their funding from Herchel Smith and still participate in the lectures and social activities of the SURF program. However, the student may not receive financial support from both programs at the same time.

Various departments and Harvard and Harvard Medical School have departmental undergraduate research programs. More detailed information about fellowships can be found on the Science Education Fellowship website.

1. PRISE is a summer residential program for Harvard undergraduates who are doing science research.
2. The Harvard College Research Program (HCRP) is administered through the Harvard College Office of Undergraduate Research and Fellowships and provides funding for undergraduates engaged in research with a Harvard faculty member in any field. HCRP does not require a full-time commitment, but the student must submit a budget that describes their work time.
3. The Herchel Smith Fellowship is administered by the Harvard College Office of Undergraduate Research and Fellowships and provides funding for students doing summer research either at Harvard or elsewhere.

All the fellowships have strict deadlines and students need to be encouraged to prepare applications in advance. For many students, it will be the first time writing a research proposal and they need to learn that proposals require several revisions before the final copy can be submitted.

Outside Sources of Funding for Undergraduate Researchers

1. NIH Grants - Under the stimulus bill, the government has announced funding to support undergraduates doing research in labs that are funded by NIH grants.
2. NSF Research Experiences for Undergraduates (REU) Program - The NSF REU program encourages undergraduate research by providing financial support to students working in any of the areas of research funded by the National Science Foundation. Undergraduate student participants must be citizens or permanent residents of the United States or its possessions.

A limited list of non-Harvard REUs is available on the Science Education website.

Research for academic credit

During junior year, students who are concentrating in the life sciences may elect to do independent research in the laboratory for credit. The course numbers and requirements differ among the departments and a more complete description of the research courses for each department can be found here. A second year of independent research for credit may be done as a senior thesis. Although a senior thesis is not required for an honors degree in most departments, many students choose to write one.

It is important to note that students may not be paid for their lab work during the same semester in which they receive course credit for research. Rising seniors who are working on their thesis research over the summer may be paid for their work since there is no academic credit associated with summer research done in labs at Harvard.

Information for hosting student researchers in the field

In the past, students have done field research at

1. Their PI's field site.
2. The Harvard Forest.
3. A field station with appropriate infrastructure
4. An independent site (i.e. one they themselves have established)

Inevitably, key parameters here are a student's independence, the ease of doing research at the site, and the ability of the student to communicate regularly with their PI.

* Many Harvard students are naturally confident that they can handle a tough novel situation, but inexperience can nevertheless be a real problem. Bear in mind that many students are inexperienced in areas that most field biologists take for granted, such as the rigors of a prolonged season without access to running water.

* It is difficult for an inexperienced student to appreciate the difficulty of doing science in the field. Often issues are purely logistical, such as site access given poor roads etc. However, others relate to the science itself. A student studying a species on which is difficult to collect data may quickly become demoralized. After all, it all looks so straightforward on David Attenborough shows. Projects should be designed with this in mind. It is a good idea to pick a topic for which a lack of data nevertheless constitutes useful information (e.g. a biological inventory of degraded habitat).

Students may find that direct communication with their PI is be impractical. In many cases, however, it is possible to recruit an in situ colleague to act as their de facto advisor.

Resources for faculty

Life Sciences Education Office

Mentoring Workshops

Advising
Life Sciences Concentration Advisors

PreMed Advising

Advising Programs Office

Sophomore Advising

Research Ethics and Safety

Cabot Library

Science Student Groups

Research Funding
Student Employment Office
Federal Work-Study Program, Faculty Aide Program

Harvard Undergraduate Research Fellowships

Harvard Winter Session

Underrepresented Minority Fellowships

Post-bac resources

International Students

Additional Resources

Harvard Resources

Writing Center

Office of Career Services

Bureau of Study Counsel

Harvard University Health Services

Office of Equity, Diversity and Inclusion

Chaplains

HUHS Counseling and Mental Health Services

Office of Sexual Assault and Prevention

Office of BGLTQ

Harvard University Police Department

HARVARD COLLEGE PEER COUNSELING

RESPONSE Peer Counseling provides confidential counseling regarding sex, consent, relationships, and any incidents of sexual or gender-based violence.

Room 13 provides general confidential counseling in person or over the phone to Harvard students.

Contact provides confidential counseling about issues of sexual orientation, sex, sexuality and relationships. They also maintain a growing library of books, pamphlets, news clippings, and magazines.

Sexual Health And Relationship Counselors (SHARC) provide confidential counseling on issues related to sexual health, contraception, STIs and testing, relationships, and dating.

Eating Concerns Hotline and Outreach (ECHO) confidentially addresses concerns surrounding eating, body image, and self-esteem.

LOCAL RESOURCES

NATIONAL RESOURCES

References and Additional Readings on Mentoring Undergraduate Researchers

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3. Handelsman, J, C. Pfund, S. Miller Lauffer, C. Maidl Pribbenow, 2005, Entering Mentoring: A Seminar to Train a New Generation of Scientists, The Wisconsin Program for Scientific Teaching.

4. Evans, Jennifer, Mentoring Magic, 2008, The Scientist, 22:12 p70.

5. Project Kaleidoscope (PKAL) is one of the leading advocates in the United States for what works in building and sustaining strong undergraduate programs in the fields of science, technology, engineering and mathematics (STEM).