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Current Developments and Funding Opportunities in Life Sciences Education

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INTRODUCTION

Both the disciplines of biology and of science education have undergone a revolution. The major focus of the biological sciences—understanding life—remains unchanged, but breakthrough discoveries of the second half of the 20th century have changed the basic nature of the questions asked, whereas new and emerging technologies are changing the ways key questions are addressed (National Research Council [NRC], 2008, 2009). In undergraduate science, technology, engineering, and mathematics (STEM) education, new approaches and new technologies are also emerging based on evolving theories of learning (Donovan *et al*., 1999; NRC, 1999, 2003). New developments in the nature of institutions of higher education have changed the manner in which people pursue higher education, and there is a growing appreciation of the need to broaden participation within the sciences by advancing the education of all students, including those from underrepresented groups and those who will enter careers other than those related to science. There is also a growing realization of the necessity to fully inform and educate all students about the wealth of professions available to those who study the sciences and about the way science is done (Alberts, 2008). This is an exciting time to be a biologist, to participate in the revolution within the sciences, and to be able to find and implement new ways to impart the excitement of biology to others. The purpose of this column is to provide readers of *CBE—Life Sciences Education* with an update on funding opportunities at the National Science Foundation (NSF) to support innovative programs in life sciences education.

CURRENT BIOLOGY EDUCATION-RELATED EFFORTS AT NSF—AN OVERVIEW[1]

The NSF was created by congress in 1950 and given a mission "to promote the progress of sci-ence; to advance the national health, prosperity, and welfare; to secure the national defense…" (NSF at a Glance; www.nsf. gov/about/glance.jsp, undated; accessed 9 March 2009). To that end, both the Directorate for Education and Human Resources (EHR) and the Directorate for the Biological Sciences (BIO) have instituted several programs, many of them jointly administered and funded, designed to support the biology community in its efforts to advance education in the biological sciences. These programs extend across the spectrum of educational levels from preschool through graduate school and include opportunities for general outreach to the public through informal science offerings in formal settings (museums and zoos) and through the media (television, radio, and other platforms).

Because of the rapid changes within the discipline and concerns about the need to incorporate these into higher education, the American Association for the Advancement of Science has recently convened a series of conversations, "Vision and Change in Biology Undergraduate Education: A View for the Twenty-First Century," as a means of determining how undergraduate biology education can best reflect both these exciting recent disciplinary advances and the knowledge we've gained about teaching and learning. These informal conversations were designed to enable a wide segment of the biological sciences community to explore the changes that need to take place and how best to effect those changes. They included, as observers and in other roles as appropriate, representatives of NSF, the Howard Hughes Medical Institute and the National Institutes of Health, National Institute of General Medicine, Division of Minority Opportunities in Research (MORE). We will report on these activities in a future article outlining the conclusions reached and suggestions made.

This article concentrates on programs designed to serve higher education through attention to

1. courses and curricula for all students—those majoring in biology and those majoring in other disciplines, those preparing to be teachers and those hoping for a career in industry, academia, or elsewhere;
2. enhancement of the pedagogical knowledge and skills of current faculty and future faculty, including greatly ex-

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perienced and newly minted faculty, as well as graduate students; and
3. programs supporting fellowships to recognize the promise and aid the progress of individual students.

The following sections start with some general guidelines regarding requests for funding and some information about recent changes in focus within existing programs or new funding opportunities at NSF. We then provide information about specific programs and specific projects funded within those programs.

CURRENT BIOLOGY EDUCATION-RELATED FUNDING OPPORTUNITIES THROUGH NSF

Pertinent higher education biology-related funding opportunities at NSF are varied in nature and scope and are described in the listings below. One of the programs listed that may be of particular interest because of its flexibility is Course, Curriculum, and Laboratory Improvement (CCLI). This program has recently been slightly revised to increase suggested funding limits within the three categories of the program, to more explicitly describe and to re-emphasize the importance of basing projects upon prior work in the field and the importance of adding to that knowledge base. In addition, a fourth category has been added to this program, Central Resource Projects, which provides opportunities to apply for funds to "assume responsibility for leadership and implementation of activities that sustain a community of practice engaged in transforming undergraduate STEM education" and to "work to increase the capabilities of and communications among the STEM education community and to increase and document the impact of CCLI projects" (NSF, 2009).

Two of the programs listed, the Interdisciplinary Training for Undergraduates in Biological & Mathematical Sciences (UBM) and the Research Coordination Networks-Undergraduate Biology Education (RCN-UBE), merit special attention because they are new and support innovative activities.

The listings below are distributed between two sections: the first contains EHR, BIO, or joint EHR/BIO programs that are specifically designed to serve biology education efforts or that have a specified budget for biology projects. The second section lists those programs that support improvements in graduate or undergraduate education generally but do fund biology-related projects among the many awarded each year. Often proposals to this second set of programs are interdisciplinary in nature and represent the efforts of a number of departments. For each program listed, the section below includes a brief description of the program and an example of a recently funded biology-related project. Information given for each project includes (within the order given here) the NSF award number (for ease of referring to it in the NSF website), the project title, a brief description of key features of the project, the last name of the principal investigator (PI), and the institution where the award is housed. For CCLI, because of its wide scope, we have listed in the text three projects funded within the past fiscal year and included a more complete listing as Supplemental Material. For details about due dates and funding limits for any one program, consult the home page of the NSF website at www.nsf.gov, put the acronym of the program in the search box in the upper right-hand corner, and then open the most recent program solicitation. Scroll down the face page for each program and use the link to recent awards to see the sort of projects that are being funded. Please note that starred items in the list of programs below are either partly concerned with graduate education in addition to undergraduate education or are completely devoted to graduate education.

In applying to education-related programs, it is important to follow the same simple rules followed for preparing a research grant:

1. State your goals and be aware of and refer to the pertinent literature that has informed your decision to follow specific approaches to achieve those goals.
2. Be clear about how you plan to accomplish your aims.
3. Consult people on your campus or elsewhere who can help you design an effective plan to gather objective data concerning the outcomes of your project.

Lack of clear plans for evaluation and lack of citations of the work of others that could profitably inform your own efforts, along with unclear descriptions of your planned implementation, are some of the major reasons why proposals with otherwise laudable goals are given low ratings.

As of this writing, the actual budget allocations for this fiscal year (October 2008 through September 2009) have not yet been made. We anticipate approximately the same level of allocation this year as last year for most of the programs described, with three exceptions. The newly passed stimulus package adds a one-time infusion of funds to the NOYCE program ($60 million) and to the Math and Science Partnerships program ($25 million). An additional $15 million has been allocated for initiating a new program (the program solicitation is still in the design stage) aimed at supporting professional science master's degree projects. Success rates for most programs listed vary between programs within any one year and between years for any one program. They can range from 10 to 30%, with most being at ~20%.

Programs Designed Wholly or in Part to Specifically Serve Biology Education Efforts

CCLI. *Purpose*. This is the broadest and most flexible program listed. It is open to all types of institutions and students, allows a focus on special targets (e.g., diversity improvements, teacher preparation, community colleges), and has a clear mission of improving the quality of undergraduate education in STEM for both nonscience majors and for majors. It is the program that encourages and supports faculty efforts to embed new scientific and technical knowledge (e.g., proteomics, bioinformatics) into undergraduate learning materials and laboratory practices. The program serves as an important test bed for introducing new ideas in teaching, new technologies, emerging sciences, and new players (some of them senior scientists) in undergraduate education. Because of its three-tiered structure, ranging from support of small starter projects funded at about $200,000 to test new ideas, to large projects of up to $5,000,000 to disseminate proven models, it has been an important means of

continually improving the quality and content of undergraduate STEM education.

Sample Projects. 0736947. *A Framework for Reasoning in Cell Biology Courses*. Developing generally useful computer gradable homework problems and clicker questions regarding photosynthesis, respiration, and genetics to stimulate classroom activity and assess student understanding. The questions are aimed at community college and college genetics courses, as well as introductory biology courses (Parker, Michigan State University).

0736966. *Integration and Dissemination of Inquiry-based Video Microscopy and Image Processing Labs into the Undergraduate Curriculum*. Designing and implementing investigative labs that incorporate various modern microscopy techniques for digital imaging and quantitative image analysis in wild and mutant strains of a model organism, *Dictyostelium*. Includes workshops for faculty on imaging techniques as teaching tools (Knecht, University of Connecticut).

0815135, 0814373. *Collaborative Research: Creating a Bean Beetle Curriculum Development Network*. Developing faculty expertise and learning materials using bean beetle (*Callosobruchus maculates*)–based inquiry laboratories; includes faculty development workshops, serves a diversity of biology subdisciplines, and includes assessment across a diversity of institutions (Beck, Emory University; Blumer, Morehouse College).

RCN-UBE: Research Coordination Networks-Undergraduate Biology Education. *Purpose.* This is a new track within the existing RCN program and is designed to support networks of groups currently working to enhance undergraduate biology education, so that biology and education researchers and practitioners working on items of mutual interest may better exchange ideas, coordinate efforts, and disseminate innovative practices.

Sample Project. 0840911. *RCN-UBE: Preparing to Prepare the 21st Century Biology Student: Using Scientific Societies as Change Agents for the Introductory Biology Experience*. The University of Oklahoma and the American Institute of Biological Sciences, in collaboration with key national biological societies, are developing a suite of activities to help their members reform their basic biology courses: 1) small face-to-face meetings to promote innovation in reform activities aimed at the introductory biology experience, 2) larger face-to-face meetings to coordinate disparate approaches in introductory biology and to increase the use of existing best practices by the members of scientific societies, and 3) a communication network linking scientific societies and their members to promote innovation and adaptation of best practices as well as research in biology education (Uno, University of Oklahoma, Norman Campus).

UBM: Interdisciplinary Training for Undergraduates in Biological & Mathematical Sciences. *Purpose.* The goal of this program, a joint effort of three directorates (Biological Sciences, Education and Human Resources, and Mathematics and the Physical Sciences), is to enhance undergraduate education and training at the intersection of the biological and mathematical sciences, to better prepare undergraduate biology or mathematics students to pursue graduate study and careers in fields that integrate the mathematical and biological sciences. All awarded projects feature long-term research experiences for interdisciplinary teams with support for at least four undergraduates, and include introduction of appropriate interdisciplinary courses.

Sample Project. 0531898. *Integrated Analysis of Genetic and Cellular Networks*. This project recruits junior undergraduate students, half majoring in biology and half in mathematics (including statistics), to conduct research developing qualitative and quantitative approaches to understanding molecular structures and mechanisms. It involves use of technical strategies from biochemistry, genetics, and cellular biology, and mathematical tools such as DNA and protein microarray analysis, data mining, dynamical systems, numerical simulation, and partial differential equations (Bates, Michigan State University).

URM: Undergraduate Research and Mentoring in the Biological Sciences. *Purpose*. To increase the number and diversity of individuals pursuing graduate studies in all areas of biological research supported by the NSF Directorate for Biological Sciences. Support is provided to academic institutions to establish innovative programs to engage undergraduates in a year-round research and mentoring activity. Particular emphasis is placed on broadening participation of members of groups historically underrepresented in science and engineering.

Sample Project. 0603049. *Training Ecologist Doctors for the 21st Century*. Underrepresented minority scholars are recruited to study three interrelated research areas central to environmental health globally and in the American Midwest, in particular, 1) the ecology and genetics of crop improvement, 2) the conservation of forest and grassland dwelling species, and 3) the ecology and management of highly impacted urban environments (Galen, University of Missouri–Columbia).

RIG: Research Initiation Grants and CAA: Career Advancement Awards to Broaden Participation in the Biological Sciences. *Purpose*. To broaden the participation of scientists from groups underrepresented in the biological sciences in the United States. Supported activities promote the development and retention of scientists from underrepresented groups to increase the numbers of such individuals who can serve as role models for the students who are the scientific workforce of the future.

Sample Project. 0615660. *Self-Organization and Robustness in Evolving Biological Networks*. The project seeks to develop fruitful insight from massive analyses of typical cellular networks of protein–protein interactions and initiates novel statistical analyses in the more general context of complex networks. The project includes curriculum development and the involvement of underrepresented minority students in the research. It is developing an interdisciplinary course on complex networks in biology and other disciplines that is tightly integrated with the research plan (Makse, CUNY City College).

RUI: Cross-cutting/NSF-wide Research in Undergraduate Institutions. *Purpose*. Supports research by faculty members of predominantly undergraduate institutions through the funding of 1) individual and collaborative research projects, 2) the purchase of shared-use research instrumentation, and 3) Research Opportunity Awards for work with NSF-supported investigators at other institutions. Eligible "predom-

inantly undergraduate" institutions are defined in the program solicitation.

Sample Project. 0515826. *Measurement of Allelochemical Dynamics in the Rhizosphere*. This project focuses on the development and application of new polymer-based materials that can trap toxic chemicals produced by invasive plants, allowing these toxins to be isolated and measured. This research is providing an inexpensive tool for other scientists to use in investigating these problems. It is being conducted by undergraduate students working under the mentorship of a faculty member at this undergraduate college (Weidenhamer, Ashland University).

CAREER: Cross-cutting/NSF-Wide Faculty Early Career Development. *Purpose*. This is NSF's most prestigious award in support of early career-development activities of those teacher-scholars who most effectively integrate research and education within the context of the mission of their organization. Such activities are expected to build a firm foundation for a lifetime of integrated contributions to research and education.

Sample Project. 0546858. *Venom Evolution in Sicariid Spiders: A System for Undergraduate Training in Integrative Biology*. This work involves undergraduates in collaborative, interdisciplinary research that spans organisms and molecules. They learn the value of approaching questions with an evolutionary (historical) perspective. In course work, the PI is 1) expanding a phylogenetic biology course that includes bioinformatics and reconstruction of tree topologies and ancestral character states, 2) creating a nonmajors arachnology course that emphasizes the value of evolutionary approaches and integrated knowledge of organisms, and 3) creating a Web-based interactive diagnostic key for *Loxosceles* and *Sicarius* species diversity that is connected to the Tree of Life website (Binford, Lewis and Clark College).

Programs to Support Undergradate or Graduate STEM Education Generally

STEP: Science, Technology, Engineering, and Mathematics Talent Expansion Program. *Purpose.* This program supports projects that will increase the number of students receiving associate or baccalaureate degrees in established or emerging fields within STEM and has a component to support research into the factors affecting students' decisions that impact choosing and remaining in STEM majors. Projects may include within their activities provision of scholarships for specific purposes.

Sample Project. 0525433. *Watershed Watch: Monitoring the Merrimac and Pasquotank Drainage Basins as a STEM Undergraduate Recruitment Tool*. Non-STEM majors are being introduced to STEM disciplines via use of geospatial technologies in an integrated, multidisciplinary study of terrestrial, aquatic, and social components of two watersheds—the Merrimack in New Hampshire/Massachusetts and the Pasquotank in North Carolina/Virginia (Rock, University of New Hampshire).

ATE: Advanced Technological Education. *Purpose*. To promote improvement in technological education at the undergraduate (with a focus on two-year colleges) and secondary school levels by supporting: curriculum development; professional development of college faculty and secondary school teachers; and career pathways between secondary schools, two-year colleges, and four-year institutions. Projects are supported at three levels: Centers of Excellence; Regional Centers and Resource Centers; and projects.

Sample Project. 0402139. *Bio-Link ATE National Resource Center*. Bio-Link's mission is to strengthen and expand biotechnology technician education at two-year colleges throughout the nation. It serves as a central distribution point for information concerning new instructional modules and for sources of free and inexpensive materials and instrumentation needed to initiate and maintain a biotechnology program (Johnson, City College of San Francisco).

NSDL: National STEM Education Distributed Learning. *Purpose*. Building on work supported under the multiagency Digital Libraries Initiative, this program aims to establish a national digital library that will constitute an online network of learning environments and resources for STEM education at all levels.

Sample Project. 0332872. *A Digital Rich Media Library of Animal Behavior*. This project provides access to the resources of the Macaulay Library, a division of the Cornell Laboratory of Ornithology, containing the world's largest open repository of recordings of animal behavior and natural history. The collection promotes increased discovery, teaching, conservation, and research (Bradbury, Cornell University).

****S-STEM: NSF Scholarships in Science, Technology, Engineering or Mathematics.*** *Purpose*. This program makes grants to institutions of higher education to support scholarships for academically talented, financially needy students, enabling them to enter the workforce following completion of an associate, baccalaureate, or graduate level degree in science and engineering disciplines. Grantee institutions are responsible for selecting scholarship recipients, reporting demographic information about student scholars, and managing the S-STEM project at the institution.

Sample Projects. 0850120. *Preparing Promising Students for the 21st Century Scientific Workforce*. This project supports scholarships that enable talented students with unmet financial needs to earn a Professional Science Master's degree in Applied Genomics and Microbial System Analysis (Strausbaugh, University of Connecticut).

0849924. *Broadening Opportunities for Biologists*. This project provides participants who are typically first generation and minority with the financial, academic, and professional development support needed to complete a degree in the life sciences (Baum, Oklahoma State University).

****NOYCE: Robert Noyce Teacher Scholarship Program.*** *Purpose*. This program seeks to encourage talented STEM majors and professionals to become K–12 mathematics and science teachers. It provides funds to institutions of higher education to support scholarships, stipends, and programs for students who commit to teaching in high-needs K–12 school districts.

Sample Project. 0630412. *Teacher Education Collaboration for High-Need Schools - New Jersey*. The project is recruiting, preparing, certifying, and helping retain a new cohort of 26 science and mathematics teachers, who, upon graduation, hold baccalaureate degrees in biology, botany, chemistry,

environmental geology, environmental science, geology, or mathematics (Bukiet, New Jersey Institute of Technology).

MSP: Math and Science Partnership. *Purpose*. This program was established in 2002 to integrate the work of higher education with K–12 to strengthen and reform mathematics and science education.

Sample Project. 0634175. *Collaborative Research: Geneticists-Educator Network of Alliances (GENA) Project*. The American Society of Human Genetics, the Genetics Society of America, the National Science Resources Center, and the National Association of Biology Teachers are using the broad theme of genetics to build a framework to form long-term collaborations between educators and scientists and a sustainable infrastructure to support meaningful outreach by scientists in the high school science classroom. The project provides the partnering scientific societies with tools to instruct, facilitate, and measure the meaningful engagement of STEM faculty members in secondary science education (Marsland, Smithsonian Institution).

****GK–12: NSF Graduate Teaching Fellows in K–12 Education.*** *Purpose*. Expected outcomes from this program include improved communication, teaching, collaboration, and team-building skills for the STEM graduate fellows; professional development opportunities for K–12 teachers; enriched learning for K–12 students; and strengthened and sustained partnerships in STEM between institutions of higher education and local school districts. The graduate fellows receive free tuition and a stipend equal to that of graduate research fellows. They are expected to work a minimum of 20 hours per week directly in the classroom with K–12 teachers and, at the same time, to maintain their research productivity.

Sample Project. 0742419. *GK–12 Fellows Linking Marine and Wetland Research with Science Education in Coastal South Carolina Schools*. The fellows, who all conduct field-based research in the multidisciplinary fields of coastal and wetland science, work directly with local teachers to bring an interdisciplinary approach to the science curriculum of local middle and high school science classrooms (Gilman, Coastal Carolina University).

****IGERT: Integrative Graduate Education & Research Training.*** *Purpose*. The program is intended to catalyze a cultural change in graduate education, for students, faculty, and institutions, by establishing innovative models for graduate education and training that transcend traditional disciplinary boundaries. It is also intended to facilitate diversity in student participation and preparation, and to contribute to a world-class, broadly inclusive, and globally engaged science and engineering workforce.

Sample Project 0549479. *Life Chip*. The overarching research theme is to promote the union of nano/microtechnology and life sciences through research, education, and outreach. Undergraduates and newly enrolled IGERT graduate students participate in an intensive summer research program helping to indoctrinate the graduate students into the project and afford the undergraduates the opportunity to learn about career opportunities, graduate school and presentation skills (Li, University of California–Irvine).

For readers who are interested in preparing projects and proposals for submission to one or more of these programs, we recommend as a first step that you access the NSF website and read the appropriate program solicitations. More targeted questions can then be directed toward the appropriate NSF program director. The names and contact information for the cognizant program directors for programs of interest can be found by searching the NSF website for the program name. NSF contacts for a given program are listed at the top of the main program page.

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