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Research Experiences for Undergraduates & Graduates at Alabama A&M and Nanjing Forestry Universities, Moss E. and Gardner L., Alabama A&M University

Alabama A&M University (AAMU) has been working to strengthen its research and education relationship with Nanjing Forestry University (NFU) in Jiangsu Province, China, since 2009, through student and faculty exchanges. Since 2012, AAMU has hosted a Research Experiences for Undergraduates (REU) program in collaboration with NFU that has both an international and a public relations twist. The program affords students an opportunity to gain research experiences alongside cultural endeavors in China. Interest in the program has increased each year with an increasingly diverse and academically astute group of students. Research is primarily focused on environmental and ecological effects of urbanization in a rapidly developing city. Students also receive training in literature searches and scientific writing, webpage production, PowerPoint poster and presentation creation, giving oral presentations, as well as a complete immersion in the Chinese culture for up to seven weeks. Students leave the program with an excellent understanding of what the entire scientific process entails, an understanding of the complexities of cross-cultural collaborations, and a better understanding of their future research focuses.

REU Site: Development of Safe Nanomaterials for Biological Applications, Vig K. and Singh S.R., Alabama State University

Nanotechnology receives a substantial amount of media attention due to its usage in newer technologies and can be used to attract new generations of students to STEM fields. The development of research experiences for undergraduate programs in the arena of nanotechnology is an important investment. This proposed REU site will host 10 undergraduate students for 10-weeks in a REU program on “Development of Safe Nanomaterials for Biological Applications” at Alabama State University (ASU), Montgomery, Alabama. ASU is a Historically Black College and University (HBCU) founded in 1867. ASU is a state-supported, coeducational, liberal arts, four-year institution with an undergraduate student population of nearly 5,700 students. All science degree programs in Biology, Mathematics, Chemistry, Physical sciences, Computer Science along a Ph.D. program in Microbiology are offered in the College of Science, Mathematics & Technology. ASU is the only university currently conducting interdisciplinary research in the area of nanobiotechnology in Alabama. This multidisciplinary model of doing research, where boundaries among departments and laboratories are removed, will be used as a teaching tool to provide quality research experiences for undergraduate students who plan to pursue careers in STEM fields. The PI, Co-PI and the Mentors have extensive experience in undergraduate teaching and training in nanobiotechnology research and have equipment for cutting-edge research. The proposed REU site program combines a rich research experience in nanobiotechnology with structured professional development. Such a program will have broad impacts such as attracting students from underrepresented groups and enhancing their probability of staying in science and pursuing advanced degrees.

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In the Canopy with Tardigrades, Herbivory and Wheelchairs, Miller W.R. and Lowman M.D., Baker University

Our 2013 REU was a collaborative research project that investigated the hypothesis of uniformity in the density, diversity, and distribution of the little known animals of the phylum Tardigrada in the canopy of Kansas. We learned and used double rope climbing technique to ascend into the unexplored canopy of the oak-hickory deciduous forest on the edge of the tall grass prairie. In the field, we climbed up to 20 meters (65 feet) into 117 trees representing 19 species. We collected 574 samples from two different habitats (mosses & lichens) at four different levels above the ground. In the lab, we extracted and imaged 4,253 tardigrades of 16 species of which four appear to be new to science. We have rejected the hypothesis of uniformity by discovering tardigrades to be significantly more common in the upper reaches of the canopy than at lower levels. We uncovered positive and negative relationships among species of tardigrade, habitats, substrates (tree species) and locations. Differential Interference Contrast (DIC) and Scanning Electron (SEM) microscopes were used to observe and measure the internal and external characteristics necessary to identify tardigrades. We have presented our results to the biology faculty of Baker University and the science staff at the North Carolina Museum of Natural Sciences. We conducted public outreach with “Water Bear Hunts” at the Overland Park Arboretum and the North Carolina Museum. Our team included students with ambulatory disabilities who climbed into the canopy from their wheelchairs. We have submitted four manuscripts to peer reviewed journals.

Hawks, Owls, Falcons, and Eagles: A new REU Site in Raptor Research, Belthoff J., Barber J., Heath J., Smith J., Bechard M., Carlisle J., Kaltenecker G., Miller R., Anderson D., McClure C., Watson R., Thorstrom R. and Perkins D., Boise State University

The juxtaposition of Boise State University’s Raptor Research Center (RRC), The Peregrine Fund (TPF), Idaho Bird Observatory (IBO), numerous state and federal natural resource agencies, and the Morley Nelson Snake River Birds of Prey National Conservation Area (NCA) has made Boise, Idaho a hub of raptor research. Boise State University is also home to the nation’s only graduate program in Raptor Biology. Our Research Experiences for Undergraduates-Raptor Research (REU-RR) Site is a new site for Summer 2014 which builds on this scientific infrastructure to provide opportunities for biological research focused on hawks, owls, falcons, and eagles (raptors). Research mentors are university and community college professors, NGO scientists, and government biologists, which provide participants exposure to multiple paths to STEM research careers. Birds of prey are attractive subjects for students and provide a basis for investigating research questions in biology fields that range from parasitology and behavior to sensory and molecular ecology. REU-RR projects focus on basic and applied raptor biology and incorporate field and laboratory investigations. Participants attend weekly journal clubs, read and discuss “Letters to Young Scientists” by E.O. Wilson, experience workshops on the biology of diurnal and nocturnal raptors, endangered species restoration, and raptor information systems, and undergo development focused on responsible conduct of research, applying to graduate school, and communicating science. Our hypothesis is that these core activities will enhance students’ understanding and enthusiasm for scientific research, increase retention of students in the STEM pipeline, and help students prepare for research in graduate school and the workplace.

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Accomplishments and Challenges: A Seven-Year Review of the REU program in PNB at UCONN, Kimball K., Renfro J.L. and Chen X., University of Connecticut

Since 2007 our UCONN PNB REU site has been providing research experience related to physiological systems to undergraduate students whose institutions offer limited research experiences. We have targeted underrepresented minorities, veterans, first-generation college students, and students with disabilities. Over the last seven years, we have been able to provide enriched research experience to a total of 67 students who completed our program. Included among the participants were 3 veterans, 2 students with disabilities who received accommodations through our Center for Students with Disabilities, and 31 underrepresented minority students. Within the past 12 months, we have been able to reach 60 of the 67 students. Seventy percent of our REU alumni have graduated from their undergraduate programs. Of these graduates, 20/47 (43%) matriculated in PhD programs and five more graduates are currently applying / interviewing or plan to apply (for a total of 53%). However, 17% of our REU alumni are currently in or graduated from medical, dental or veterinary school. We examined our current data, including participants' prior research experience, articulated career goals, GPA, etc., as well as the original applications and letters of reference to investigate if there is any commonality among those students who do go on to PhD program. Our preliminary results indicate that prior research experience is associated with student's eventual progression to PhD programs. Funding sources: NSF REU program and the University of Connecticut College of Liberal Arts and Sciences.

REU Site: Plant Genome Research, Hua J. and Jander G., Cornell University and Boyce Thompson Institute

Students participating in this REU program learn to design and implement experiments that take full advantage of available plant genome resources, as well as cutting-edge molecular and biochemical research methods. Recruitment of summer interns occurs through direct mailings to biology departments throughout the United States, contact with former REU students, postings on websites, and attendance at SACNAS and other meetings. Particular emphasis is placed on recruiting students from small colleges without significant research infrastructure and underrepresented minority students. Among 152 previous participants in this REU program, 57% were from small colleges and 39% were underrepresented minority students. In exit surveys, most the summer interns reported a good (20%) or great (74%) gain in their understanding of laboratory research, 89% had an increased interest in the subject area (plant biology), and 93% had a moderate to great gain in their confidence to do research. Most former interns (92%) "agree" or "strongly agree" that this internship program helped to prepare them for graduate school, and 85% were more likely to go to graduate school due to their experiences. More than 90% of former REU students are tracked for at least five years via Facebook, email inquiries, contact with former faculty mentors, and phone calls. After college graduation, there is a steady progression of these students into graduate degree programs and subsequent scientific careers. Overall, more than 80% of students who participated in the REU Site: Plant Genome Research have completed graduate degrees in a science-related field.

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Delaware State University-NSF REU site: Seven Years of Experiential Learning in Molecular Genetics, Melmaiee K., Kalavacharla V., Wiggins B., Hankoua B., Sabanayagam C., Ozbay G., Dhillon H., Lee J., Chintapenta K., Davis L., Everett L., Harrington M., Temburni M., Quadros-Mennella P., Elavarthi S., Taylor S., Mennella T., Smolinski T., Ayyappan V., Fondong V. and Liu Z., Delaware State University

The Research Experiences for Undergraduates Program (REU) at Delaware State University (DSU) has been successfully held for the last seven years from 2007 through 2013. Our 9- week summer research experiences program has been focused on molecular genetics and genomics. Students with diverse backgrounds were recruited from institutions throughout the United States, including our partner institutions Delaware Technical Community College and Wesley College. A wealth of faculty from a broad spectrum of life science research areas including plant biology, genetics, biotechnology, plant virology, neuroscience, aquaculture, and food safety served as mentors. In the first couple weeks, students underwent rigorous methods workshops to familiarize themselves with tools and techniques in molecular biology and genomics. While continuing their research in their mentor's laboratory, students developed a research proposal, and presented their progress to their REU peers and faculty mentors on a weekly basis. Students were provided opportunities to participate in seminars given by government, academic and industry scientists, visits to biotechnology organizations, and interaction with various levels of scientific researchers. Additionally, at approximately two-week intervals, the REU students attended four ethics seminars on various ethical issues in natural science research. The student research projects concluded with the DSU undergraduate research symposium where students from DSU-wide programs participate in a combined event. From FY2007 to FY2013, the DSU REU program trained approximately 70 students from diverse backgrounds, with approximately 68% of the students being female participants and 54 % coming from underrepresented minority population. The DSU REU website can be found at (<http://cars.desu.edu/reu/index.htm>).

Studying the Macrophyte-Microbe Interaction in the Salt Tolerance Mechanism of Marsh grass species, Ozbay G., Chintapenta L.K., Kalavacharla V., Schirtzinger S., Clark K., Dixon C., Wiggins B. and Everett L., Delaware State University

Spartina alterniflora, the native marsh grass species is being dominated by the invasive marsh plant *Phragmites australis*. This Invasion causes a shift in saltmarsh ecology and its associated microbial communities. Our goal is to study the microbes associated with native and invasive marsh grasses. Exploring the microbial community helps to understand if any microbes or microbial genes play a major role in salt tolerance mechanism of *Spartina*. This study explains plant-microbe interactions and also an overview of their role in plant survival under stress conditions. This might help in understanding the survival mechanisms of terrestrial plants under salt stress in near future. Molecular studies were used to identify the bacteria and fungi associated with marsh grasses. Sediment nutrient composition with relation to the native and invasive marsh grasses was studied from the pore water samples. Specific fungi were identified in *Spartina* and diverse marsh areas which also had high levels of nitrogen and phosphorous. Further detailed study might result in interesting results.

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National study of the impacts of graduate / postdoctoral mentoring of undergraduate researchers, Dolan E., Aikens, M. and Sadselia, S., University of Georgia

Many undergraduate researchers are mentored by graduate or postdoctoral researchers (postgraduates), who themselves are mentored by faculty. This unique mentoring configuration has not been the focus of empirical research even though it is commonplace in academic settings and faculty and postgraduate mentors are likely to have unique and important effects on undergraduate protégés. We are conducting an NSF-funded national study to get at this. Our approach involves surveying “triads” – undergraduate researchers and their postgraduate and faculty mentors. We are surveying undergraduates about their research experiences and their interactions with postgraduates and faculty. We are also surveying postgraduates and faculty about their interactions with the undergraduates and each other, and about the undergraduates’ learning. Results of this work will yield unprecedented insights into the latitude we have for designing undergraduate research experiences, especially for women and students of color. We would like to include data from REU sites so that we can understand the mentoring of undergraduates in these important training programs, as well as how mentoring influences student outcomes. We need your help in recruiting undergraduates; they will receive \$20 for participating. For REU sites that have at least eight (8) complete triads responding, we will provide a summary report to the PI (with individually identifiable information removed) regarding the quality of mentoring in the program and the gains undergraduates have realized from their research experiences. Please stop by our poster for more information.

Insights into a Summer Research Experience using Pre- and Post-Evaluations, Patel M.V., Rose B. and Ellison A.M., Harvard University

Since 2006 the Harvard Forest Summer Research Program in Ecology has administered pre- and post-program student evaluation surveys to assess (1) acquisition and enhancement of scientific research skills; (2) satisfaction with the REU learning experience; and (3) post-program plans for STEM education and career development. During the Forest’s 11-week residential program, 20-30 students from a range of disciplines, backgrounds, schools, and skill levels are immersed in mentor-supervised projects, participate in educational workshops, and attend career and graduate school panels. Students’ survey responses indicate they make substantial gains in the core skills of conducting research, analyzing data, and presenting findings. Most students gained new experience participating as part of a team working on interdisciplinary ecological research projects. Approximately 50% of students each year show a change in post-graduate plans. For example, most of the students who report at the beginning of the summer that they have plans to attend graduate school in ecology/environmental science have changed their mind by the end of the summer and report then that they intend to study or work in non-environmental fields after graduation. However, our longer-term (2001-2013) longitudinal data reveal that > 80% of our participants remain in ecology or environmental-related graduate degree programs or jobs.

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The Pacific Internship Programs for Exploring Science: Changing the Face of Conservation in Hawaii, Puniwai N., Ziegler-Chong S., Ching M. and Ostertag R., University of Hawaii at Hilo

In 1994 the Micronesian & American Samoan Student Internship Program pioneered an internship model which focused on placing undergraduate students from the islands of Micronesia and American Samoa into a structured, academically rigorous, and heavily mentored program back on their home islands for summer internships. Over the last 20 years, that single program is now combined with the University of Hawaii Hawaiian Internship Program and the NSF supported Research Experience for Undergraduates and collectively known as the Pacific Internship Programs for Exploring Sciences. We target (1) minority students (Native Hawaiians/Pacific Islanders in particular), (2) first-generation college students, (3) students with little to no research experience, and (4) students with a sincere desire to do conservation science research that gives back to local communities. Our program has been successful in providing students with a quality cohort research experience, broadening their academic and career horizons, gaining real scientific research skills, and developing an understanding of the issues and approaches to tropical conservation. 78% of our 452 program alumni are continuing their education, completed advanced degrees, and/or become influential members of the conservation community.

A Pilot Project to Engage Underrepresented Minority Students in a Research Experience, Barcnas N.M., Heritage University

Heritage University (HU) is successfully testing a new approach to increase the participation of underrepresented minorities in research experiences. HU, a private, liberal arts, Hispanic Serving Institution serves the Yakima Valley from its location on the Yakama Indian Reservation. A common problem of students historically under-represented in STEM disciplines is that many are place bound for cultural reasons and/or by family obligations. This severely limits their ability to go away for the 8-10 weeks of most REU Sites around the country. To overcome this problem, HU has partnered with several institutions to offer research experiences locally (so students can continue to live at home); or relatively close (so students can come back home during the weekend). Partners include Universities (UPS, UW, WSU, PNWU); an USDA-ARS Laboratory; a NSF Science and Technology Center; and the Yakama Nation Fisheries. The REU program also includes an academic-year component that prepares participants for the summer research experience (pre-REU) and follows them afterwards (post-REU) to share and reflect on their experiences, and to prepare them to present their research at National Conferences. In the first two years HU REU has served 18 students (39% Hispanic; 33% Native American; 61% women; 72% First Generation College). 100% of HU-REU students gave oral and/or poster presentation at HU and 89% at National Meetings (SACNAS, AISES, and AAAS). In addition, REU participants are actively involved in outreach activities at Tribal and other local schools, where they serve as important role models.

Impact of NSF-REU Research Program on Undergrad Education and Success in Biology at Hope College, Fraley G.S., Best A., Barney C.C., Bultman T.L., Burnatowska-Hledin M.A., Chase L.A., Murray K.G., Li J., Putzke A., Stukey J., Winnett-Murray K. and McDonough-Stukey V., Hope College

The Hope College Biology department has had the privilege of hosting an REU Site since the inception of the REU program at the NSF, and REU remains an integral part of our biological research. Our most

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recent REU Site, “Environmental Impacts on Biological Systems: From Molecules to Ecosystems,” sought to demonstrate how environmental changes can impact all levels of biology. Students in this program were not only active researchers; they participated in weekly discussions about ethics, scientific writing and presenting, and held regular field trips and social events. Students also had the opportunity to present their research at local, regional, and national scientific conferences. This NSF-REU Site funded 36 students over 5 years of which 53% were non-Hope students, 55% were women, and 64% were from underrepresented groups. Over this 5-year funding period, the faculty of the Biology department published 112 manuscripts that included over 200 students as co-authors; virtually all of the NSF-funded researchers earned authorship on scientific publications. During this time, the Biology department graduated an average of 48 students per year of which 25% went on to graduate school, another 10% went into the science work force and 44% went into one of the health professions. Assessments of our REU-funded summer research program have indicated that students believe that research at Hope College was a vital part of their success in post-graduate education and ultimately in their chosen careers. Thus, the Biology REU Site at Hope College has positive impacts on many different careers in biology.

Paying it back: training young scientists to connect with the public that funds them, Wilson G., Pruyn M. and Fahey T., Hubbard Brook Research Foundation

The REU program at Hubbard Brook is run jointly by Plymouth State University (PSU) and the Hubbard Brook Research Foundation (HBRF), with research mentors being drawn from the pool of scientists active in research at the Hubbard Brook LTER site. The program capitalizes on the long history of policy-relevant research conducted at the site, as well as PSU’s position as a regional, outreach-focused university, by weaving training in communicating science to non-technical audiences through the 10-week mentor-guided independent research. Weekly science communication seminars provide the opportunity to focus on case studies including the HBRF’s Science Links policy outreach project, the site’s K-12 focused Environmental Literacy Program, and the Hubbard Brook Roundtable series, which brings scientists and ecosystem user-groups together for mutually-informative dialog. Students interact with scientists, teachers, and professionals engaged in communication with non-technical audiences and gain practice doing so themselves by hosting a program blog and offering research tours to students from the local school district. Student research projects are diverse and selected to cover the range of ecosystem research at Hubbard Brook, including animals, soils, hydrology, biogeochemistry, and forest vegetation.

REUs in animal behavior at the Center for the Integrative Study of Animal Behavior, Hurley L.M., Martins E.P. and Demas G.E., Indiana University

This poster will focus on the details of multiple strengths of the REU site program in animal behavior run by the Center for the Integrative Study of Animal Behavior (CISAB) at Indiana University, located in south-central Indiana. These strengths include a large and diverse pool of applicants from nationwide, a program-long series of career development exercises, and access to internationally recognized labs. Research conducted by interns may encompass the mechanisms of behavior including learning, sensory, neural and endocrine systems, as well as behavioral ecology and the evolution of behavior. A multi-tiered mentoring system pairing interns with faculty members, with graduate students or postdocs, and in some cases with high school students, is coupled with tier- appropriate training in research or

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mentorship. This model promotes the flow of information and skills among multiple career levels. Our desired outcome is a set of interns with strong abilities to produce and present behavioral research, and with reinforced skills for navigating the transition to post baccalaureate education and beyond.

REU Site: Models in Evolution, Ecology and Systematics, Gleason J.M. and Mort M.E.,
University of Kansas

During the summers of 2013 through 2015, the REU site program will bring ten students to the Department of Ecology and Evolutionary Biology at the University of Kansas to participate in mentored research. We are targeting both biology majors and math or computer science majors interested in biology. Our theme centers around the use of models, broadly interpreted. The more mathematically inclined students build biological models to be tested computationally. Other students examine biological models that have been proposed and test them experimentally. The students share their perspectives on model building and testing in weekly meetings and journal clubs. In this manner, students develop an appreciation for the application of quantitative skills to biology and the importance of quantitative skills for biological research. In our first year we recruited students from across the country that attended very different institutions. The experience of the students in the program ranged from having completed one year of community college to being one semester away from graduation. Despite this diversity, all of the students reported significant gains in science knowledge and research support skills. The students presented their research in talks for an audience of biologists, poster for the university community and a video intended for a general audience. Mentor-student interactions are continuing and at least half of the students are currently working on preparing their research for peer reviewed publications.

Two Decades of Undergraduate Research in Ecology, Evolution, and Genomics at Kansas State University, Snyder B.A. and Morgan T.J., Kansas State University

The Kansas State University (K-State) Biology REU program currently provides opportunities for independent undergraduate research examining the mechanistic responses of organisms to changing environments. Specifically, research projects in the program investigate the genetic, physiological, developmental, and ecological mechanisms which mediate responses to novel environments. Based in the Division of Biology at K-State, the program represents a synergistic collaboration with the Konza Prairie LTER site and the Ecological Genomics Institute. The program takes a holistic approach to summer undergraduate research training by including a seminar series on modern approaches in ecology and evolutionary biology; professional development seminars; training in responsible conduct of research; field trips to important biological sites, museum collections, and genomic centers; and multiple oral presentation opportunities. These shared activities help build a rich cohort experience for our students. We have an extensive history with nearly 200 students who have participated in the K-State Biology REU Site. Long-term tracking demonstrates great success of former REU participants in graduate school and beyond. The K-State Biology REU Site continues to partner with other programs on to support student research. These programs have included supplemental awards to mentors, the McNair Scholars program, The Ecological Society of America's SEEDS program, and K-State Graduate School's SUROP program. As the K-State Biology REU begins its third decade of undergraduate research, the program will continue to build off the existing strengths, while modifying the programmatic focus to

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keep our undergraduate training at the cutting edge of mechanistic ecological and evolutionary biology research.

Kentucky's "Suburban Ecology and Invasive Species": Mechanisms for Successful Mentorship, Westneat D.F., Bouwma-Gearhart J. and Xiang L., University of Kentucky

Our site program focuses on embedding talented undergraduates into original research on organisms that are invasive or are impacted by invasive species. Entering our third year, we have averaged 127 applicants per year. Our 20 interns to date reflect the make-up of the applicant pool, providing diversity in some respects but limiting it for traditional under-represented groups. Our program provides multiple mechanisms of mentorship, with applicant surveys revealing the most rewarding aspect of the program occurred when interns were embedded in research groups with frequent interaction with both faculty and graduate students (the latter were viewed as "intermediaries" and as more accessible for questions), with the intern being given more independence over time. This approach increased student confidence regarding their ability to conduct and report research and helped inform their post-graduate goals via a better understanding of everyday scientific research work. Group discussions had more limited impact, with sessions addressing how to present research and applying to graduate school deemed most meaningful. Finally, excursions that blended outdoor activities with some educational/cultural value helped to produce strong cohort effects and fostered richer interactions with faculty. Multiple projects from both years appear headed toward publication with interns as co-authors. We continue to experiment with ways to mentor scientific creativity.

Biological Discovery in Woods Hole, Mensinger A.F., Marine Biological Laboratory

The Biological Discovery in Woods Hole (BDWH) Program is an intensive, ten-week summer research experience for undergraduates at the Marine Biological Laboratory (MBL), in Woods Hole, MA. The marine setting and unique intellectual blend of investigators provides a diverse undergraduate research experience. The goals are to recruit highly motivated students, especially from under-represented groups and/or schools with limited research programs, and immerse them in independent research programs under the guidance of mentors that are fully committed to enhancing undergraduate research experience. The program averages over 400 applications per year which has resulted in successful recruitment of students from underrepresented groups in science (60%), and from institutions with limited research opportunities (70%). The SALG assessment provided valuable feedback to optimize the student and mentor experience with participants routinely rating program components very good or excellent. The student's undergraduate research symposium was broadly disseminated via live streaming to allow the general public or students/faculty at their home institutions to view the presentations. Program alumni have reported high success in graduate school admission. A minority faculty member was recruited as a scholar in residence, and has secured funding to join the program as full time mentor. A local middle school teacher received two RET grants, and incorporated the research into her curricula and provided the REU students an overview of K-12 education. Our goal continues to be to recruit a cohort of students as diverse as the research environment, and to significantly enhance their science education and research experience.

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Enhancing Student Understanding of Estuarine Dynamics Using an Orientation Research Cruise, Allen M.R., Jones T.W., Clark J. and Moser F.C., Maryland Sea Grant College

Since 1989, as part of an introduction to estuarine ecology, Maryland Sea Grant REU students have engaged in an annual orientation research cruise that follows a salinity gradient up the Patuxent River, a tributary of the Chesapeake Bay. Students are introduced to basic concepts of Chesapeake Bay ecology through pre-cruise seminars, chemical and biological data collection on the ship, and post-cruise data interpretation. Field collected data reinforce the concepts of thermal and chemical stratification and provide first hand exposure to the complexities of estuarine dynamics. Here, we reconstruct 12 years of archived cruise data to develop an integrated dataset for use as a teaching tool to introduce students to interannual variation in estuarine processes. Data show major interannual differences in stratification and light regimes, giving students a sense of the system's variability. By incorporating long-term monitoring data into the interpretation, students gain an understanding of how the measurements they collect can be influenced by larger-scale processes, such as weather events, that operate at different scales. Students consistently rank the research cruise as a high point of their orientation.

REU enrichment activities promoting growth as scientists and citizens, Rypstra A.L., Campbell K.U. and Berg D.J., Miami University

Enrichment activities provide critical "value-added" aspects to REU site programs. As a result, students participating in such programs often receive an experience that is much more than those provided by REU supplements. The theme of our program, "Ecology in Human-Dominated Landscapes", is woven into nearly all of the activities throughout the summer. Our REU participants develop as global citizens with a respect for the role that humans play in shaping the future of our planet while they grow as individual scientists who are part of a scientific community. Members of the Myaamia Institute at Miami University help the students experience the relationship that their people have with this landscape and the native understanding of ecology. This connection and its implications are contrasted with western views in ethics sessions throughout the program. Field trips and exercises provide a view of the landscape as it is now and myriad ways in which it is impacted by anthropogenic activities. Individual research projects are conducted in collaboration with faculty mentors and student mentor pairs cooperate with others working on related research in clusters that meet regularly. These interactions further their ecological understanding of human impacts and enable the participants to grow as scholars who present and publish their work. The activities of scientists are further explored through a course entitled "Principles of the Scientific Profession," as well as training in scientific and environmental ethics. Our post-program surveys verify that participants and mentors both place great value on these enrichment activities.

Student Recruitment for the Summer Undergraduate Research Programs at the University of Minnesota, Juliussen E. and Schottel J., University of Minnesota

The Life Sciences Summer Undergraduate Research Programs (LSSURP) oversees and coordinates several programs in the life sciences including the NSF-REU in Molecular Genetics and Proteomics. The programs begin with a joint orientation weekend followed by participation in a research project under the direction of a faculty mentor at the University of Minnesota. Special activities are focused on professional development and opportunities for social interaction. The summer research experience

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concludes with a poster symposium and closing program. LSSURP is designed to recruit highly qualified students to graduate programs in the life sciences.

Evolution of a Botanical REU Program at the Missouri Botanical Garden, Bogler D., Missouri Botanical Garden

The Missouri Botanical Garden REU in "Plant Systematics, Conservation Biology, and Ethnobotany" is currently in its third year. MBG opened in 1859 and occupies 80 acres in downtown St. Louis. MBG offers extensive collections of horticultural plants, a herbarium research collection of 6.3 million specimens, an excellent library, laboratory facilities for DNA and SEM analysis, dedicated PhD research scientists, and a 2,400 acre nature preserve. A major goal was to reach out to groups that are underrepresented in the botanical sciences, so an effort was made to recruit from Missouri's Historically Black Colleges and on the Great Sioux Reservation, where one MBG research project is located. Over half of the REU students were from underrepresented groups the first year. The program was structured like the parts of a scientific paper and paced accordingly, which ensured the students were prepared for their final poster and symposium presentations. Projects included: economics of urban medicinal plant production; ethno-veterinary treatment of horses; DNA barcoding; describing new species of tropical plants; conservation genetics and seed germination studies of threatened plants; use of pollen and seed morphology in taxonomy; and ecology of invasive plants. We have learned valuable lessons about recruiting early and aggressively for minorities, developing an ethics in research component, matching students with mentors and project difficulty, handling staff changes, travel reimbursement, negotiating management turnover and conflicts with other Garden programs, working with mentors from local universities, assessment, and student tracking. The program has positively impacted the lives of students.

The Future of Natural Gas: A Millennial Perspective from NSF REU Scholars, White D., King S., Soetan N., Silva M., Kramer L., Choquette K., Lahey C., Colon T., Becker J., Kurgan G., Marquez A., Gaffigan B., Cerutti H. and Blum P., University of Nebraska-Lincoln

Here we report on the outcome of a novel STEM approach for promoting undergraduate scholarship involving one cohort of NSF REU students at the University of Nebraska in 2013. Using a student centered approach, they prepared and presented an extensive review on the policy behind natural gas (NG) utilization and its impact in the United States then formalized this as an essay and refined it for subsequent publication. They discussed the implications of increased production of NG with respect to economics, foreign affairs, regulation and the environment all from their perspective as the Millennial Generation. This project allowed these students to team on a collaborative intellectual project with a bioenergy focus while considering sustainability and the implications on their human generation. Key to their efforts was the daily integration of their intensive research experience derived from many distinct laboratories whose research focused on bioenergy from basic to applied aspects. They concluded that increased US natural gas consumption necessitates that goals be put in place to help ease the US into promoting energy independence and environmental safety. The subsequent publication and overall process encourages this REU to further explore this novel approach to STEM education.

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REU for Rural & Tribal College Students: Recruiting Efforts & Impact on Educational & Career Paths, Doze V., Conway P., Sens D., Cisek K., Boeckel J., Hanson B., Olimb S. and Wages J., University of North Dakota

The Research Experience for Undergraduates (REU) in Neuroscience for Rural and Tribal College Students at the University of North Dakota has been in existence for nine years. Our experience has been consistent with the observation that undergraduate years are critical for engaging students in research, to increase the number pursuing STEM careers. Research opportunities at home institutions are sparse for rural and tribal college students, underrepresented in science. To date, nine student cohorts have completed a 10-week summer research experience. Highlights of our program include the leveraging of resources to include additional students in the summer experience, recruitment and selection efforts that reach our target demographic, and an evaluation model that utilizes pre- and post-surveys and focus groups. This allows us to not only review strengths and weaknesses of the program and track student outcomes, but also to examine factors contributing to students' entrance into science and health careers. Students report high impact in terms of strengthening lab skills and increased scientific literacy and self-confidence. A significant number of rural and tribal students have progressed to post-baccalaureate programs. We assessed the influence of the research experience and other factors, personal, family, and community, on student career choices. Analyzing these factors has allowed a better understanding of the contribution of undergraduate research experiences to post-undergraduate study and career choices.

Ohio State REU in Biochemistry and Molecular Genetics, Cole S.E. and Simcox A.A., The Ohio State University

The Ohio State REU in Biochemistry and Molecular Genetics has been continuously funded since 2006. Our goals are to maximize participation of students from groups underrepresented in science and from small colleges with limited research opportunities. An additional goal is to strengthen the credentials of students with average academic records, especially those from underrepresented groups. Over the three years of completed funding in the current grant, we have mentored 35 participants, 60% of whom self identify as members of one or more underrepresented groups, and 50% of whom come from non Ph.D.-granting institutions. Group activities designed to increase student engagement and program cohesiveness include an introductory workshop, weekly journal clubs, and end-of-program presentations. Ethics seminars led by a professor from the Department of Philosophy cover issues from research ethics in the lab to societal impacts of human cloning, and are a particular strength of the program. Strong institutional support, including a stipend for our ethics seminar leader, summer salary for a co-PI, and administrative support have further strengthened the program.

Sharing infrastructural elements - University of Oregon REU Site Program, O'Day P.M. and Yablok S., University of Oregon

The University of Oregon REU Site Program in Molecular Biosciences offers a ten week summer experience for visiting interns to work on closely mentored research projects, integrating research and education. It aims to contribute to national efforts to raise competence in STEM areas, enhance access to research careers, broaden participation in STEM research and train graduate students and

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postdoctoral fellows to be effective mentors. REU interns acquire experience-based education develop appreciation of experimental approaches, strategic design, and creative reasoning, develop methodological, critical reasoning, and communication skills, boost personal confidence by professional and social interactions with faculty, postdocs, and grad students, and gain insights into graduate education and research environments. In the course of two funding cycles, we have developed and improved infrastructural elements that we share with BIO REU colleagues, with the aims of offering discussion and feedback to improve REU program infrastructures generally.

NSF-REU at Penn State Harrisburg-Towards a Secure and Sustainable Energy Future, Potlakayala S., Shuler A. and Rudrabhatla S., Penn State University-Harrisburg

Thanks to the support of the NSF-REU program, over the last two years Penn State Harrisburg's School of Science Engineering & Technology has had the opportunity to work with 20 students who participated in our 10 week research program at our state-of-art labs and greenhouses. Our intellectual theme, titled "Towards a Secure and Sustainable Energy Future", allowed the students hands on experience on projects that focused on genetic engineering and molecular genetics of biofuel crop plants with goals to increase biomass or add traits to increase biofuel production. In addition to their scientific merit, the 10 weeks we spent with the students gave us an opportunity to provide guidance to those students looking to pursue a career in the sciences and produce the next generation of scientists. Our key accomplishments include:

- Demographics include 16 female students and 10 minority students of a total of 20 students.
 - 6 of 14 students that graduated are continuing their education in graduate school; 3 are working in scientific industry and 3 are currently studying or applying to graduate school in sciences
 - 8 students shared authorship in posters presented at an international conference; 10 students presented in national conferences; and 9 students presented regionally
 - Supplementary funding for high school students (RAHSS) recruited a total of 9 students from local high schools. Two of the 4 students from year-1 program stayed in science for their undergraduate degrees and the remaining 5 students are yet to graduate from high school
-

Tiered Mentoring and Training in a Medical School-housed Computational Biology REU, Ayooob J.C., Gentile K., Russel L. and Chennubhotla C., University of Pittsburgh

Computational biology incorporates interdisciplinary approaches and harnesses the power of computation to tackle emerging big data challenges and answer questions in biology not amenable to traditional experimentation. Given the interdisciplinary nature of the field, mentors in the TECBio REU @ Pitt program span several departments. This diversity is also reflected in the academic backgrounds of our students whose major disciplines include life, physical, and computer sciences, and engineering. This breadth of expertise is a boon for our emerging field as it presents opportunities for increased interdisciplinary discourse within our program. It also presents a challenge of how to most effectively reach and maximize the mentoring experience for our students. To address this, we have begun utilizing a Tiered Mentoring and Training (TMT) framework. TMT provides summer students with numerous opportunities to learn from multiple faculty, postdoctoral fellows, graduate students, and other summer undergraduates from a variety of areas and perspectives. These interactions also provide important professional development opportunities for these early-stage and nascent investigators, who will be future teachers and mentors. Additionally, TECBio students also serve as mentors for a group of high

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school students who participate in a parallel summer research program. We envision the formalization of a TMT framework as a means to more effectively reach an academically-broad group of students to enhance their experiences, and also as a means to lower the burden on faculty, without decreasing their interactions with students, and help recruit additional mentors, instructors, and others to participate in and augment undergraduate research programs.

The Rice University REU in Biological Networks: a site for students in science and engineering, Silberg J.J. and Bennett G.N., Rice University

Biological research has made great strides in identifying the genes, proteins, and metabolites that underlie life and creating rough roadmaps for how these molecules function individually and collectively through networks of interactions. However, we cannot yet anticipate a priori the dynamic behaviors of evolvable systems because our understanding is not sufficient to explain the intricacies of biological processes using fundamental principles of chemistry and physics. To overcome this, biologists are increasingly drawing upon principles from diverse science, technology, engineering, and mathematics (STEM) disciplines and integrating experimental biochemical, cell biological, and molecular genetic approaches with higher level mathematical data analysis, computational design, simulation, and modeling in their studies. We run an interdisciplinary summer experience that bridges these areas by providing research experiences for undergraduates majoring in disciplines as diverse as Biology, Chemistry, Computer Science, Engineering, Mathematics, and Physics. We will describe how we recruit students pursuing such diverse majors to our REU site, how we match these students with biological research mentors who also have diverse training and ongoing interdisciplinary projects, and how we structure our summer experience to maintain a cohesive community. In addition, we will describe our efforts to use this interdisciplinary site to stimulate student creativity and build collaborative skills at an early stage of student's education. Furthermore, we will describe recruiting strategies that we identified as critical for increasing the number of applicants from community colleges that lack research experiences.

REU site: Computational Biology Summer Program at Rutgers-Camden, Taylor K.D., Piccoli B. and Martin J.V., Rutgers Camden

The project's major activity consisted in providing a unique integrated research experience during summer 2013 for 10 undergraduate students performing research on computational biology at Rutgers-Camden, within the framework of the Center for Computational and Integrative Biology. The 10 weeks summer program included the first three weeks of training. The participating students increased their skills and knowledge in lab and field research activities, enthusiasm for and interest in scientific research, writing and presenting research results and collaborative teamwork. Other major achievements included the production of written reports (one for each student) and a poster (one for each group, total of four). The research from one project gave rise to a paper published in BMC Plant Biology.

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SFSU: Research in Environmental Studies and Evolutionary Developmental Biology, Cohen C.S. and Domingo C., San Francisco State University

The San Francisco State University (SFSU) REU program provides a summer research experience for students, particularly URM students, in the emerging interdisciplinary field of evolutionary developmental biology in an environmental context. Our targeted student population is students who have completed at least one year of college-level biology, have not had significant prior research experience, and are interested in pursuing a science career (PhD). Each summer, our REU site program supports 10 students in a cross-campus 10-week program. REU supplement and other interns, including early career secondary teacher research interns, often join aspects of our program. To build cohort synergy and to promote the intellectual theme of integrating across evolution, ecology, and development, the students have a pre-research orientation week of activities including laboratory and field exercises with model and non-model developmental systems and comparative life histories. Activities include manipulation and visualization with a diversity of invertebrate and vertebrate early developmental stages, a group-designed field or lab exercise in sampling early developmental stages to test the effects of environmental variation, and a sampling cruise on San Francisco Bay with mentors in biological oceanography and marine ecology. Other cohort experiences include a multi-day camping trip to the Sierras or outer coast, a career workshop, and shared ethics training with other Bay area REUs. Now in the fifth year of our program, we have tracked students moving from community colleges through completion of 4-year undergraduate degrees and into graduate research programs.

Preparing the Next Generation of Scientists: Professional Training in Global Change Ecology at SERC, Gustafson Jr., D.E., Parker J.D. and Hines A.H., Smithsonian Environmental Research Center

The Smithsonian Environmental Research Center is one of the Smithsonian Institution's largest research and education-based facilities and has an overall mission of revealing the biological and physical processes that sustain life on earth. Our REU program focuses on global change, including climate change, biological invasions, altered biogeochemical cycling, and native biodiversity loss. Particular attention is paid to the Chesapeake Bay, the nation's largest and most commercially valuable estuary. Since 2001, the SERC REU program has sponsored 185 students, including 30% under-represented minorities, the majority of whom use this as a stepping stone to further advance their careers in the environmental sciences.

Our program is a 12-week period of hands-on field research, laboratory work, and educational training to: (1) identify an unanswered question in global change biology, (2) devise a testable hypothesis, (3) conduct a research project, and (4) share the discovery with the professional community. Interns also take a series of short courses describing scientific methods, ethics, and careers, participate in graduate-level discussion groups, and attend seminars by visiting scientists.

Interns also benefit from experiential field trips to Smithsonian Museums and Galleries on the National Mall as well as interactions with other interns in the Institution. The students are further encouraged to participate with other research labs as an exchange to broaden their depth and understanding of research disciplines. At the end of their internship, each intern will present a formal research seminar, and many present at national/international conferences and publish in peer-reviewed journals.

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Ethical Decision Making: A Critical Component of REU Training, Boettcher A. and Turrens J.,
University of South Alabama

The NSF-REU Structure and Function of Proteins Site at the University of South Alabama provides training of students in the research process with a focus on integrative projects at the junction of biology, engineering, and chemistry. Research projects focus on protein chemistry, and are collaborative with pairs of students working on two aspects of the same project and interacting with faculty from all three disciplines. One component of the program involves students' training in ethics and responsible conduct of research. The process begins on the first day of the program when the students complete an on-line training module focused on responsible conduct of research. This allows the students to become familiar with the terminology and sets the stage for weekly face-to-face sessions that focus on key areas of training identified by the Office of Research Integrity. These sessions are small and include only the NSF-REU students and a discussion leader. The sessions are informal and occur over lunch, which promotes open discussion. Students receive case studies ahead of time, which are included in the discussion. In addition, our NSF-REU students are included in our university-wide summer undergraduate research workshop series, which focuses on various aspects of professionalism and includes students from all disciplines across the university. Students are encouraged to discuss issues brought up at the professionalism workshops with their mentors, reinforcing lessons-learned. At the conclusion of the program, students are asked to evaluate the program as a whole, including specific aspects related to their ethics training.

REU Coastal Ocean Systems and Sustainability: Year 1 Strengths, Kim D., Heidelberg K. and
Marinelli R., University of Southern California

The USC Wrigley Institute for Environmental Studies (WIES) successfully ran the first year of the Coastal Ocean Systems and Sustainability REU program in 2013. Eight NSF-funded students and three additional students, funded by WIES and USC Dornsife College, participated in the 8-week program at the Wrigley Marine Science Center on Catalina Island, CA. A major strength of the program was the interdisciplinary nature of the REU. For example, student projects included conservation genetics of key coastal species, physiology of harmful algal bloom species, an evaluation of CO₂ cycling in coastal habitats, geospatial mapping of coastal environments, stress response in bivalves, and oceanographic time-series analysis. Training was also provided in cross disciplinary tools and concepts (e.g., GIS, oceanographic sampling, career tools). The program was also successful in recruiting target students by participating in conferences, listservs and panels that specifically target underrepresented students. The first year's cohort consisted of five sophomores and six juniors, four minority students, three first generation college students and one recent transfer student from a 2-year institution. Other strengths of the program included a REU Handbook that clearly outlined goals and expectations for students and mentors, pre- and post-program surveys for students and mentors that provided valuable insight during planning and evaluation stages, the integration of synergistic activities with other programs, and active social media to engage and maintain contact with students. Our inaugural year was also helpful training for the organizers, and we look forward to continue providing high quality training for the next ocean science cohort.

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Microbial Community Interactions and Functions REU: A Successful First Summer in Knoxville, TN, LeClerc G., Buchan A., DeBruyn J., Zinser E. and Wilhelm S., University of Tennessee

The University of Tennessee-Knoxville (UTK) REU program “Microbial Community Interactions and Functions” is actively preparing for its sophomore year. This REU got off to a great start in its inaugural summer. 10 participants were accepted from a pool of 160 applicants. Students from seven states and Puerto Rico came to Knoxville, TN in early June, 2013. Six women and four men (four from underrepresented minority groups) participated in the REU program.

Students were carefully matched with a faculty mentor and a graduate student “sibling”. The careful selection of students and mentors resulted in a research experience in which all REU students, graduate students and faculty enjoyed and benefitted greatly. 100% of REU participants felt that the REU experience prepared them for advanced course work and/or graduate school. After the 10 week program, 70% of participants were much more likely to enroll in a master’s program and 50 % were much more likely to apply to a Ph.D program. 100% of the graduate student siblings and faculty members stated they would be willing to mentor another REU student in 2014.

All three REU participants that were entering their senior year applied to the UTK-microbiology graduate program. The productivity of our REU participants was very high as well. REU participants are already co-authors on 2 papers and 1 book chapter that have either been published or are in preparation for publication. For 2014 we look to build upon the success of our first year and enhance interactions with our REUs on campus.

Tuskegee University Research Experiences for Undergraduates (REU) Participants as Near-Peer Mentors, Bolden-Tiller O. and Alexander A.D., Tuskegee University

The TU Integrative Biosciences (IBS) REU site was initiated in Summer 2009 with the express intention of providing undergraduate students with a meaningful research experience in integrative biosciences. Many of the program participants have limited research experience and spend the first two to three weeks focusing on the “why” and “how” of their projects. In 2004, Tuskegee University introduced a two week summer enrichment program for high school students (AgriTREK/SciTREK Summer Institute – Tuskegee Research Enrichment Kamp in Agriculture and Science) which afforded these individuals to participate in a micro-research project with a specific focus, for instance development and validation of new primer pairs. Reports indicate that irrespective of the form in which research training occurs, the ultimate goal is for a budding scientist to develop the research and analytical skills that may ultimately result in a research career. Further, the incorporation of peer mentors and near-peer mentors reportedly enhance research experiences, resulting in these individuals more quickly moving from novice researchers to experts. In an effort to help facilitate the progression of IBS REU participants from novices to experts, AgriTREK/SciTREK scholars were included in research labs where IBS REU students were housed with them serving as near-peer mentors as appropriate. IBS REU participants who worked with AgriTREK/SciTREK scholars were queried about the impact of having high school students interact with them in the research lab. The feedback was primarily positive and here we highlight a specific case that demonstrated the positive impact that resulted from the near-peer mentor relationship.

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REU students gain training and experience in K-12 science education outreach, Haynes K.J. and Lutzow-Felling C., University of Virginia

As an ecological research station and the State Arboretum of Virginia, Blandy Experimental Farm combines university level research and environmental education of the public. The REU program has been linked to youth education by having REU students develop a short teaching unit, based on their summer research, for use in the Blandy Summer Nature Camp program. The program provides an opportunity for REU students to mentor and teach younger students the science skills and knowledge they are developing during their REU experience. Approximately 75 children, ages 6-12, participate in a week-long environmental science program. Each REU student participates in one day of the camp to share some aspect of his/her REU research through a hands-on activity. REU students are mentored by Blandy education staff to prepare them to interact with summer camp participants, to think of ways they can share their knowledge and skills with elementary and middle-school aged children, and to develop an interactive, inquiry-based activity. Following their interactions with the children, the REU students meet with education staff to receive feedback on the strengths and weaknesses of their teaching approach and to assess what they learned from the experience. In 2012-2013 exit surveys, 70% and 30% of REU students reported "great" or "good" gains, respectively, in learning from the training and experience they received in science education outreach.

Vision and Change Core Concepts and Nested Learning Communities Unify a Large REU Program, Moyer-Horner L., Wassarman D. and Branchaw J., University of Wisconsin-Madison

The Integrated Biological Sciences Summer Research Program (IBS-SRP) at the University of Wisconsin-Madison has grown significantly over the past 10 years to provide research experiences to over 50 students each summer across several biological sciences sub-disciplines. This growth in numbers and breadth created an opportunity to develop a unique program model that encourages faculty ownership across campus through a series of nested learning communities and connections across these communities through the Vision and Change Core Concepts (AAAS, 2011). Individual students in the program belong to a series of nested learning communities, at the heart of which is their research group and their research mentor. Students are also part of small disciplinary sub-groups, which provide the cohort, faculty-led, weekly learning experiences at the core of a traditional REU program. A common process-based curriculum, Entering Research (Branchaw, 2010), and the Vision and Change Core Concepts create connections across these disciplinary sub-groups. A seminar series, led by faculty experts from across campus, introduces students to the Core Concepts and subsequent work in their faculty-led disciplinary sub-groups and with their research mentors help them to connect the concepts to their individual research projects. Across all of these learning communities is the campus-wide Summer Research Opportunities Program (SROP), a residential learning community hosted by the Graduate School that hosts research students across all disciplines. In addition to support for undergraduates, the IBS-SRP also offers the Entering Mentoring (Handelsman, 2005) seminar, which creates a learning community to train and support research mentors.

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REU Site: Integrated Research at the Frontiers of the Biological, Physical, and Engineering Sciences, Noble D.B., Regan L.J., and O'Hern C.S., Yale University

Yale University's REU Site: Integrated Research at the Frontiers of the Biological, Physical, and Engineering Sciences provides research training for undergraduates for ten weeks during each summer. Since 2011, 34 students have participated in our program of which 11 were under-represented minorities and 19 were females. Students are placed in laboratories of PI's who are affiliated with Yale's Raymond and Beverly Sackler Institute for Biological, Physical, and Engineering Sciences and apply physical and quantitative approaches and methodologies to answer open questions in the biological sciences, spanning the mechanics of cellular processes, protein function and misfolding, and method development such as novel fluorescence and microscopy techniques. Our program immerses students in graduate-level research in an environment of a large research institution and prepares students for the graduate school admissions process. The program also features a series of workshops aimed at improving the communication and research skills of participants, and discussions about scientific ethics and best practices that include responsible authorship and publication, peer review process, confidentiality, data and image manipulation, and plagiarism. The ethics training incorporates elements based on the presentation by Prof. Pijanowski at the 2012 NSF Bio REU meeting and utilizes active learning. In addition, students deliver a final oral presentation based on their research projects to an interdisciplinary audience of other undergraduates, graduate students, post-doctoral fellows, and faculty, and receive anonymous feedback. Students also give practice talks during which they receive direct feedback on their presentations from post-doctoral fellows with diverse scientific backgrounds.
