

Evaluation of an Undergraduate Neuroscience Research Program at the University of Kentucky

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For the past 12 years the Department of Anatomy and Neurobiology at the University of Kentucky has run an interdisciplinary neuroscience research experience for undergraduates. Over the years the programs funding sources and participant numbers have steadily increased, to a total of 16 undergraduates in the summer of 2003, supported with internal funds, state funds, and a Research Experience for Undergraduates site grant from the National Science Foundation. The goals of the UK summer research program include: 1) provide an interactive environment for faculty, graduate students and postdoctoral scholars where undergraduates from non-tier one research universities are exposed to the many facets of a graduate career, 2) inform undergraduate students of the career opportunities available in the field of neuroscience, 3) increase the numbers of

underrepresented minorities, first generation college students and students from non-tier-1 colleges and universities admitted to graduate programs in the biomedical sciences, and 4) immerse undergraduate students in a research project of their own choosing in departmental and non-departmental faculty laboratories that cover a wide range of neuroscience research. Student placement in academic medicine graduate programs, student satisfaction surveys, return students, high numbers of women and minority participants, and an ever-increasing national interest in the program are all indicators of the programs success.

Key words: undergraduate; interdisciplinary neuroscience; research experience for undergraduates; summer program; academic-medicine.

The summer research experience for undergraduates program at the University of Kentucky (UK) was started in 1992 and was originally funded with intramural funds. Since 1994 the UK summer research program has benefited from funding from the National Science Foundation (NSF), in the form of an NSF Research Experience for Undergraduates (REU) site grant. The goals of the UK summer research program, administered through the Department of Anatomy and Neurobiology at UK, include: 1) provide an interactive environment for faculty, graduate students and postdoctoral scholars where undergraduates from non-tier one research universities are exposed to the many facets of a graduate career, 2) inform undergraduate students of the career opportunities available in the field of neuroscience, 3) increase the numbers of underrepresented minorities, first generation college students and students from non-tier-1 colleges and universities admitted to graduate programs in the biomedical sciences, and 4) immerse undergraduate students in a research project of their own choosing in departmental and non-departmental faculty laboratories that cover a wide range of neuroscience research.

Since its inception, the program has had five separate components in which all students participate: 1) a short course in basic neuroscience that includes an orientation to library informatics at UK, 2) independent research projects, 3) weekly lunchtime seminars by faculty and graduate students, 4) a summer symposium on spinal cord injury and head trauma, and 5) oral presentations at the end of the summer describing the results of the student's independent research.

Orientation and the Neuroscience Short Course

This component of the program occupies the students for the first five days they are on campus. Lunch is provided to the participants by the department on all five days. The Neuroscience Short Course (NSC) is taught by faculty members that normally teach in departmental neuroscience courses or that specialize in a related area. The lectures are presented two per morning over the first three days of the program. The purpose of the NSC is to familiarize students with the vocabulary of neuroscience. This helps bring all participants to a similar level of knowledge and facilitates their understanding of the upcoming faculty research presentations. More in-depth instruction is provided in the laboratory chosen by the student for his or her research project. The topics to be covered in the short course include: cellular biology of the nervous system, peripheral and central nervous system anatomy, neurophysiology, nervous system development, neuroendocrinology, and the biology of neurodegenerative diseases. The afternoons of the first three days are used to orient participants to the department and all of the department/college core facilities that they might have occasion to use. The medical center library gives students a two-hour informatics course to familiarize them with literature searches, various databases, and library holdings.

Selection of an Independent Research Project

At the completion of the NSC and orientation, faculty members give 20-minute presentations describing the general focus of their research and potential projects for the summer students. The program now involves faculty from a wide-range of neuroscience-related fields from

seven different departments at UK. Thus our students have a broad cross-section of research fields from which to choose that still fall under the broad definition of interdisciplinary neuroscience. At the end of the presentations the students are given half a day to meet with faculty and tour their labs as well as use the UK library facilities to investigate possible projects. The students rank their choices of labs/faculty and submit them for approval. The Program Coordinator attempts to match each student with his/her top choice. In only three occasions over the course of the program have students had to work in the laboratory of a faculty mentor that was not their first choice. Further, if after a week in lab a student feels mismatched, they are moved to another laboratory from the group of available faculty members. This has occurred on only two occasions over the course of the program.

The student and faculty mentor each receive information so that they are both aware of the expectations of the UK Summer Research Program. Together, they design a research project with the goal that publishable data will be generated by the end of the summer. The project will, in most cases, be part of a larger project in which the student will be contributing one facet, or a pilot project investigating an offshoot of the main project. By designing projects that may result in authorship, students feel that they may have contributed to the laboratory as a whole. All students in the program have 24-hour access to the laboratories in which they work. The goal of publishing has stimulated students to become totally immersed in their research, spending additional time in the laboratory at night and on the weekends.

Friday lunchtime seminars, core facilities tours, and recreational outings

Every Friday students gather with the program director and other faculty for lunch provided by the Department. Most Friday sessions are used in part, to discuss the student's progress and concerns about the program. Beginning on week two, sessions are devoted to discussing a one-page research proposal written by each student in collaboration with his/her mentor. On week four, these proposals are revisited and an update of students', successes, failures, misadventures, and other items of note are presented. Other sessions are used by faculty and graduate students to discuss how to apply to graduate school and the life and times of graduate students. Faculty members are invited to discuss career options for someone with a Ph.D. in the life sciences, emphasizing opportunities in teaching (at all levels), public service, and private industry. The MD-PhD track is always a popular presentation. On week eight the session is devoted to the preparation of a professional presentation. PowerPoint instruction is available in the department for those who require this assistance.

There are a number of core facilities at UK that employ researchers and are of interest to summer students.

These include the Nuclear Magnetic Research (NMR) Center, Transgenic Core Facility and Macromolecular, Magnetic Resonance Imaging and Spectroscopy Center (MRISC) and an Imaging/Structure Facility. Each of these facilities gives regular tours to interested students and faculty. Summer students are taken as a group to view ongoing research at each of these centers. The NMR and MRISC centers have equipment for both human and small animal studies and their directors arrange for tours describing recent advances in NMR/MRI and how NMR and fMRI can be used for research. The transgenic facility provides tours in which students get to try their hand at injecting DNA into mouse embryos *in vitro*.

The summer research program at UK not only exposes students to actual laboratory work and related scientific experiences, but also seeks to expose undergraduates to the various social and personal aspects of a career in academic medicine, which leads to an understanding of collegiality. Because of its location, students at UK have a wide range of outdoor activities available within a 60-mile radius. Students are encouraged to bond socially. Trips to see baseball games, amusement parks, aquariums, and museums are popular weekend activities. The Red River Gorge and Mammoth Cave National Parks are always popular with those who like outdoor activities. In addition, the Department holds numerous social activities over the summer: a scramble golf tournament at a local golf course, 4th of July party, and BBQs at faculty homes and local parks.

Summer Symposium

The annual summer symposium takes place in July near the end of the summer when the student's level of understanding is maximal. The original symposium in which our students participated had at least three researchers give formal seminars, followed by an informal reception in the evening that has been attended by students and faculty. Previous symposia have highlighted nervous system growth factors (Heidi Phillips, William Snider, Christine Gall); spinal cord injury (George Martin, Michael Schwartz, Marion Murray), and signal transduction in cell birth and cell death (Dale Bredesen, Keith Crutcher, Richard Smyne).

For the last three years our students have been encouraged to attend the annual Kentucky Spinal Cord and Head Injury Research Trust (KSCHIRT) conference in lieu of hosting our own symposium specifically for our summer program participants (infominded.com/kscirc/). The KSCHIRT conference site alternates between Lexington, KY and Louisville, KY each year and has several advantages over our own 'in house' symposium, including: 1) allows students to attend an actual neuroscience research conference with an international audience, 2) guarantees student exposure to a large variety of research efforts, philosophies, personalities, techniques, etc., and 3) saves the program money by only

having to pay student registration, transportation, and accommodations (every other year) rather than covering the costs associated with hosting a private symposium.

Although our students have decreased interaction with scientists at the larger KSCHIRT conference than the smaller UK symposium, we feel that the experience better exposes them to the life of a scientist, illustrating that one of the highlights of any career in the sciences is the opportunity to interact with colleagues from around the world at annual conferences. This change in the program has been well-liked by our summer participants as indicated from written comments on the end-of-summer student satisfaction surveys.

Oral presentations

During the last week of the program the summer students give oral presentations describing the results of their research. The presentations are expected to be professional and from 10-12 minutes in length to allow time for questions from an audience consisting of any medical center personnel who choose to attend the publicly posted talks. The students are encouraged to utilize PowerPoint, generated in collaboration with their research mentor. Students routinely practice their talks in front of technicians and graduate students from their respective laboratories. Practice sessions are encouraged, as most undergraduates have not made public presentations. The medical center faculty has been exposed to many highly-polished summer-student presentations, both technically and in delivery. A number of the participants have used their results to get credit for lab-based courses at their home institutions and some have also gone to national science competitions presenting the research they accomplished while in the Summer Research Program at UK.

Year	Minorities	Female-Male	Non-Tier 1	UK Funded	Total Students
1998	31%	69%-31%	85%	23%	13
1999	15%	77%-23%	62%	15%	13
2000	17%	75%-25%	67%	17%	12
2001	39%	54%-46%	77%	23%	13
2002	39%	77%-23%	62%	23%	13
2003	38%	63%-37%	50%	25%	16
<i>totals</i>	30%	69%-31%	66%	21%	80

Table 1. Characteristics of summer research participants from 1998-2003.

METHODS

Students

An ever-growing list of savvy students has found our program's contact information on the web at various sites including the NSF's REU Program Site listing (<http://www.nsf.gov/search97cgi/vtopic>), our departmental research program listing (http://webdev.mccs.uky.edu/medicine/neurobiology-new/sum_research.htm), and a host of other institutional website lists including: MonsterTrak.com, the Faculty for Undergraduate

Neuroscience site, and the Psi Chi National Honor Society site to name a few. Over the last three years the number of completed application packets (electronic application, two letters of recommendation, and transcripts) has steadily increased. There were 42 in the summer of 2001, 53 for the summer of 2002, and we received 57 completed application packets for the 2003 summer program, out of which only ten students are invited to participate.

Faculty

When the program began, faculty participants/mentors were limited to faculty whose primary appointment was in the Department of Anatomy & Neurobiology at the University of Kentucky College of Medicine (UKCOM). As our numbers of student participants continued to grow so did our faculty mentor pool. It remains one of the program's goals to offer students a wide range of laboratories to choose from for their summer research. We now have a truly multidisciplinary neuroscience research focus, which includes faculty from physiology, biology, psychology, biomedical engineering, and communications.

Housing

NSF participants are selected from a nationwide pool of applicants. Therefore part of the budget is set aside for travel and a portion is set aside for housing out-of-town participants. Departmental/state funded students generally tend to be local, only once have departmental funds been necessary to house one of these local participants. For the entire 12 years of the program our participants have been housed on the UK campus in graduate students housing. The apartment style housing has been well liked by the participants; adjacent to the UK arboretum and a short walk to the medical center, every unit has a kitchen, two cable modems, a dining room, a living area, and all participants have their own bedrooms.

RESULTS

Since the summer of 1998, the UK Summer Research Program has brought 80 students to UK for the summer. At least one summer participant per year is a return student; these seasoned participants (typically mature participants from the previous year that excelled and wished to return for another summer of research) assist new participants in learning the nuances of the program. With the return students included we have an average of thirteen students per summer (Table 1). The program has averaged four underrepresented minority students per year (30%; Table 1). 55/80 participants have been female (69%; Table 1). Participants have joined us from 75 institutions, of which 53 are considered non-tier 1 research institutions (66%) as defined by the 2000 Carnegie classification system (www.carnegiefoundation.org). As of our latest update of our participant's success, 19 are still in undergraduate programs, 22 are in graduate school programs, eight are now in professional school, ten are

applying to graduate programs, two are high school science teachers, and five are research technicians (Table 1; 14 students are not included as they were return students or we have lost track of them).

Our 30 different faculty mentors come from a total of seven different departments and were selected from a pool of over 50 faculty members that were willing to select students over the six years of the present study.

In an attempt to formalize our continual refinement of our summer program, we began conducting an annual end-of-the-summer survey in 2000. The results of which are presented in Table 2 (N=23).

Results of Summer Research Experience Exit Survey	
<i>Administered at the end of the summer, students are instructed <u>not</u> to include their names on the forms.</i>	
<i>1= Strongly agree, 2= Agree, 3= Disagree, 4=Strongly Disagree</i>	
Statement	Ave. \pm S.D.
Before entering the summer research program I was planning on applying to graduate school	1.8 \pm 0.4
Now that I have completed the summer program I am more likely to apply to graduate school	1.9 \pm 0.6
Before entering the summer program I was planning to apply to medical school	2.6 \pm 1.1
After completing the summer program I am less likely to apply to medical school	2.4 \pm 1.0
After this summer I am planning to pursue a career outside of science (e.g. law, business)	3.4 \pm 0.8
Prior to this summer I had considered graduate school at the University of Kentucky	1.8 \pm 0.9
After my experience this summer I plan to apply to graduate school at UK	1.4 \pm 0.6
If I go to graduate school, it will be to study some aspect of neuroscience	1.7 \pm 0.6
After my experiences this summer, a career in research is more attractive	1.3 \pm 0.5
The individual presentations that we made at the end of the summer were very beneficial	1.4 \pm 0.7
Departmental faculty were responsive to my needs	1.1 \pm 0.5
Housing arrangements were sufficient	1.0 \pm 0.2
I would recommend this program to a friend	1.6 \pm 0.7
The method used to choose the lab I worked in was appropriate	1.9 \pm 0.9
I am interested in attending a University with an MD/PhD program for medical school	2.5 \pm 1.3

Table 2. Results of the end of the year summer program evaluation (N = 23).

DISCUSSION

Over the past six summers the Undergraduate Summer Research Program at UK has provided the opportunity for 80 undergraduates interested in a bench research experience the opportunity to participate in a tier-1 neuroscience laboratory experience. The goals of the program are several fold, and include increasing the numbers of underrepresented minorities, first generation college students and students from non-tier-1 research schools admission to graduate programs in academic medicine.

49% of our summer participants are either now in or are currently applying to graduate programs in academic medicine. While the remainder are either still in school as undergraduates (29%), are working in science (11%;

science teacher or laboratory technician), or are in professional school (11%; medical or pharmacy school). Given the fact that all of our participants already had an interest in the sciences and an interest in either academic or clinical medicine, it is not possible to conclude that our program is responsible for this high level of success in nurturing interest in the field. However, as the program is designed to expose interested students to a career in academic medicine, it is clear that students were not disappointed in what they were exposed to, that participation in the program may have played a role in the high admission rate by strengthening applications, and that students rated the program very highly on their end-of-the-summer surveys.

One of the obvious successes of the program was the ability to involve a large percentage of underrepresented minorities in neuroscience research. In fact, of our 24 minority participants, a full 78% have ended up in graduate (13) or professional (6) programs, the rest are still undergraduates at their home institutions. Although many of these participants may have ended up in academic medicine without involvement in our program, active minority recruitment has facilitated what may be a difficult process, particularly for underrepresented minorities.

REU site projects are encouraged to involve students who might not have the opportunity to participate in bench research, therefore recruitment should focus on attracting a significant fraction of participants from outside the host institution and strive to increase the participation of women, underrepresented minorities and persons with disabilities (Singer et al., 2003). Minority recruitment remains a top priority of the NSF-REU program, and as such is our biggest challenge. Although we invited students from all over the country into our summer program, most of our participants do come from regions in and around Kentucky – regions with a relatively low minority population. Our most successful minority recruitment efforts have centered on establishing relationships with Historically Black Colleges and Universities (HBCUs), such as Kentucky State University (KSU) in Frankfort, KY. KSU has provided our program with several gifted minority participants that may otherwise have not had the opportunity to participate in tier-1 neuroscience research.

Kentucky and the surrounding areas have a large population of first generation college students. Although we do not formally track the numbers of first generation college student participants, we do use it as a factor in considering applications. Participation in the program has lead to a continuous stream of applications each year from several liberal arts college in Kentucky, Ohio and Tennessee.

Table 2 presents the exit survey results from 2001-2003. After the program is completed, students are asked to complete the survey anonymously prior to leaving for home. Students are generally willing to complete the survey, however getting them returned to us in a timely

fashion at the end of summer has proved to be problematic. As the result of a 55% survey return rate the data in Table 2 has been generated on only 23 participants.

Survey results indicate several key findings. The first is that participation in our summer research experience has made it more likely that participants will apply to graduate school. On a related note, the program has made it less likely that students will apply to professional or technical school clinical medicine programs. While participation in the UK research experience may strengthen a professional or technical school application, this is not a goal of UK or of the NSF-REU program. Combined, these two self-reported trends are encouraging and support the theory that exposure of students to a research experience in academic medicine makes it more likely that they will develop an increased interest in it as a career. Further, the program has encouraged many (15) students to apply to or become enrolled in the graduate program at UK.

Finally, as indicated by Table 2, students felt that they accomplished a lot during their summer, they felt the program worthy of recommendation to a friend and that other aspects of the program such as the faculty mentor selection process and housing were acceptable. Perhaps an even more tangible appreciation for student satisfaction and accomplishment can be gained from knowing that our summer students have participated in the authorship of 22 peer-reviewed publications since 1998.

In sum, the Undergraduate Summer Research Program at UK has contributed to an increase in interest in academic medicine amongst several underrepresented groups, including: minorities, females and first generation college students. Participants have been very satisfied with the program's infrastructure, mentoring process, housing and other program characteristics.

REFERENCE

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Received August 07, 2003; revised October 01, 2003; accepted October 14, 2003.

This work was supported in part by the National Science Foundation, grant #1106406, the Kentucky Young Summer Scientists Program, the Bucks for Brains Program, and the Psi Chi National Honor Society. The authors thank the neuroscience research faculty at the University of Kentucky for their efforts in support of the program.

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