

A Biomedical Engineering Research Experiences for Undergraduates Program at Purdue University

Karen M. Haberstroh, and Thomas J. Webster

**Department of Biomedical Engineering
Purdue University, West Lafayette, IN 47907-1296**

Introduction

A recent study by the U.S. Department of Labor concluded that highest need for engineers in the next decade will be in the biomedical sector, with 33% more jobs projected by the year 2008¹. Clearly, programs are needed to increase the number of qualified and diverse engineers trained in biological sciences and/or medicine for the year 2008. For this purpose, the objective of the present study was to increase exposure and interest in biomedical engineering for students (particularly, females and underrepresented minorities) who would not normally have such opportunities.

Materials and Methods

To provide undergraduate student exposure to biomedical engineering-related research, the authors of the present study applied for and obtained a National Science Foundation award for a Research Experiences for Undergraduates (REU) program at Purdue University. Undergraduate students (US citizens or permanent residents) having completed at least 4 semesters of education could apply for admittance to the program through an on-line web-site (<http://www.ecn.purdue.edu/BME/REU>). Students were mentored throughout the 10-week summer program by faculty advisors and graduate students in a research area chosen by the REU student. REU participants were required to attend weekly lab meetings (within their own research labs and as part of the REU student group) aimed at providing research updates and project feedback. In addition, halfway through the summer, students prepared and presented 4'x6' research posters to Purdue faculty, staff, and students. At the program's culmination, students gave formal, 30-minute long oral presentations to Purdue students, faculty, and staff, as well as visiting faculty from the REU students' universities.

Exposure to Clinical Medicine

In a novel manner, the REU program at Purdue University gave clinical exposure to all student participants. Specifically, students watched at least two surgeries (in most cases, related to their research project) during the summer, followed medical doctors on clinical rounds, and partook in a panel discussion (run by medical students, residents, fellows, and

practicing MD's). This experience was geared towards providing students with first-hand knowledge of what contributions they could make as biomedical engineers in a clinical environment. Medical personnel at Indiana University School of Medicine at Indianapolis provided the support necessary for such activities.

Exposure to Industry

In addition to exposure to a clinical environment, REU participants were given the opportunity to witness the life of a biomedical engineer in industry. To accomplish this, participants visited two well-known area industries (Zimmer, makers of biomedical implants, and the pharmaceutical company, Eli Lilly) and learned about various tasks within the companies. Through this process, each student became aware of the wide range of roles a biomedical engineer partakes in an industrial setting.

Exposure to Academia

One aspect of our REU program was to promote undergraduate students to complete research-oriented graduate degrees. To emphasize this, participants were given the opportunity to determine what contributions biomedical engineers could make to academia. By conducting research in a university setting throughout the summer, students gained valuable experience on "university-life" from a faculty/research-scientist point of view. Moreover, all REU students participated in a panel discussion with university faculty and graduate students to determine what it takes to get into graduate school, and to learn more about qualifying exams, preliminary exams, dissertation, tenure-track positions, *etc.*

Results and Discussion

Ten undergraduate students were accepted to the first summer of our REU program and conducted biomedical engineering related research at Purdue University for a ten-week time period during the summer of 2001. Projects ranged from biomaterials (3 students), biomechanics (3 students), bioimaging (2 students), bioseparations (1 student), and computational cell modeling (1 student).

Highly qualified students participated in our program from a wide range of universities across the country including Cornell University, The University of Pittsburgh, The Johns Hopkins University, Saint Louis University, Clemson University, University of Portland, The Ohio State University, Stevens Institute Of Technology, University of Maryland-College Park, and Rose-Hulman Institute of Technology. Half of these institutions currently do not have an established BME program; more importantly, seven of the students were not biomedical engineering majors at their own university. This diverse group of ten students had an average GPA of 3.58 (max = 4.0, min = 2.7), and consisted of six females, four males, and three underrepresented minorities.

Survey results provided evidence that REU participants were extremely pleased with the program. Examples of average survey results (on a score of 1 through 5, with 5 being the highest) are shown in Table 1.

Table 1: Average BME REU End-of-the-Summer Survey Results

Survey Question	Score
Professional Development	4.7
Personal Development	4.9
Specific Research Advisor	4.7
Specific Research Project	4.6
Laboratory Facilities	4.4
Clinical Tours/Exposure	4.9
Industrial Tours/Exposure	4.3
Academic Exposure	4.8
Diversity in Program	4.7
Poster Presentation	4.8
Podium Presentation	5.0
Social Activities	3.9
Gained Knowledge	4.9
Usefulness of Weekly Lab Meetings	4.2
Bioethics Seminar	4.1
Overall Program`	4.9

Positive comments included organization of the program, respect given to the students, enjoyment of hospital and industry trips, helpfulness of advisors, level of responsibility assumed/given, and the extremely rewarding experience of conducting research during the program.

Most importantly, one-on-one exit interviews with students demonstrated that (compared to opinions prior to beginning the program) REU participants were more likely to enroll in BME graduate programs at the conclusion of the summer program.

In addition to being extremely well received by student participants, the REU program in biomedical engineering at Purdue University was also productive. To date, the research conducted over the summer by these outstanding students has resulted in five papers that have either been submitted or are in preparation for publication in highly respected biomedical engineering related journals. Moreover, four abstracts will be presented or have been presented at biomedical engineering related conferences. (Listing follows, with REU student names underlined).

Publications resulting from the REU summer program:

Brathwaite R., Kaefer M., and Haberstroh K.M., “The effects of hypoxic conditions on kidney cell functions,” (In Preparation).

Elsamra S., Record R., and Badylak S., “Laminin in porcine derived extracellular matrix scaffolds induces PC-12 differentiation,” (In Preparation).

Elias K. L., Price R.L., and Webster T.J., “Enhanced functions of osteoblasts on carbon nanofiber compacts,” submitted to Biomaterials (2001).

Kay S., Thapa A., Haberstroh K. M., and Webster T.J., “Nanostructured polymer:nanophase ceramic composites enhance osteoblast and chondrocyte adhesion,” Tissue Engineering, in press (2002).

Record R., Hodder J., Elsamra S., and Badylak S., “The effect of extracellular matrices on PC12 differentiation,” Tissue Engineering, submitted (2002).

Conference presentations resulting from the REU summer program:

Savaiano J., June G., Kay S., and Webster T.J., “Nanocomposites increase functions of chondrocytes,” to be presented at the Materials Research Society Annual Spring Conference, San Francisco, CA 2002.

Kay S., Thapa A., Haberstroh K. M., and Webster T.J., “Osteoblast and chondrocyte adhesion on nanostructured polymer:nanophase ceramic composites,” to be presented at the Society for Biomaterials meeting, Tampa, FL, 2002.

Price R.L., Elias K.L., Kennel E.B., Haberstroh K.M., and Webster T.J., “Carbon nanofibers as osteoblast-specific implant materials,” presented at the Biomedical Engineering Society Conference, Durham, NC, 2001.

Record R., Hodder J., Elsamra S., and Badylak S., “The effect of extracellular matrices on PC12 differentiation,” presented at the 1st Biennial Meeting of the European Tissue Engineering Society and the 4th International Meeting of the Tissue Engineering Society International, 2001.

Student Follow-up: A Semester Later

In early January of 2002 (one full semester after completing the Purdue biomedical engineering REU program) each of the ten participating students were contacted and asked questions related to their experiences following the program. Sample questions and responses (with 7/10 students responding) are shown below. Results verify that the REU program was successful, and did contribute to student confidence, interest, and excitement in biomedical engineering.

- 1) What is your current year in undergraduate studies? 2 (*completed Dec. 2001*), 1 (*senior*), 4 (*junior*)
- 2) Are you conducting research at your own university this year? 5 (*yes*), 2 (*no*)
- 3) Are you conducting BME-related research at your own university this year? 5 (*yes*), 2 (*no*)
- 4) If yes, did your experience in the REU program encourage you to conduct research at your own university? 4 (*yes*), 1 (*somewhat*), 2 (*N/A*)
- 5) If no, did your experience in the REU program discourage you from conducting research at your own university? 2 (*No: It did not discourage me, I just have no time for it in my schedule now; I am studying abroad this year*), 5 (*N/A*)
- 6) If you are conducting BME-related research now, is it related to the research you conducted as part of Purdue's BME REU program? 2 (*yes*), 3 (*no*), 2 (*N/A*)
- 7) Are you applying to graduate school now? 4 (*yes: 2 completed undergraduate studies in Dec. 2001, 1 senior, 1 junior*), 3 (*no: 3 juniors*)

- 8) Are you applying for another type of advanced degree now? 1 (*yes: junior*), 6 (*no: 2 completed undergraduate studies in Dec. 2001, 1 senior, 3 juniors*)
- 9) Do you plan to apply to graduate school next year? 2 (*yes: 2 juniors*), 5 (*no: 2 completed undergraduate studies in Dec. 2001, 1 senior, 2 juniors*)
- 10) Do you plan to apply for another type of advanced degree next year? 2 (*yes: 2 juniors*), 5 (*no: 2 completed undergraduate studies in Dec. 2001, 1 senior, 2 juniors*)
- 11) Do you see more "real-world" relevance in your courses after completing the REU program? 6 (*yes*), 1 (*no change*)
- 12) Has your GPA improved after attending the REU program? 4 (*yes*), 2 (*no change*), 1 (*N/A: studying abroad*)
- 13) Has your interest in BME related research increased since attending the REU program? 6 (*yes*), 1 (*no: I think I became more interested in the "biomedical" side of the field and will most likely be pursuing a graduate degree in cell biology or a related discipline.*)

14) Additional comments?

Ricky Brathwaite: REU helped to enhance my awareness of how certain facets of my education could be implemented to affect positive change. It helped to narrow my focus and increase my desire to be all that I want to be.

Anna Burgner: I thought that it was a great program to have participated in! I have recommended to several other students who are considering Biomedical Engineering Graduate School that they should apply!

Thomas Lozito: My REU project involved cell modeling. I never considered modeling as an interest, but after the summer I became involved in two modeling projects.

Mary Waller: The entire experience, both the research and the chance to see the clinical and industrial applications, has greatly increased my interest in BME. I plan on pursuing a career in BME.

Katie Jansen: Although I am now steering away from BME, it had nothing to do with my experience this summer. The most important thing is that this experience did make me decide to go to graduate school and pursue research as a career. As I have said before, it was a very rewarding experience that has given me a lot of confidence in myself. I would not have changed much about the program at all.

Sarina Kay: The Purdue program was a wonderful opportunity to experience a lot in a short amount of time. We were exposed to a lot of different things related to our field that were very helpful when looking at grad school programs and other research opportunities.

Acknowledgements

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References

- 1) <http://www.whitaker.org/glance/outlook.html>

Biographical Information

KAREN M. HABERSTROH

Dr. Karen M. Haberstroh is an assistant professor in the Department of Biomedical Engineering at Purdue University. Dr. Haberstroh received her bachelor's degree in 1995 in Biomedical Engineering from Brown University, and her MS (1996) and PhD (2000) in Biomedical Engineering from Rensselaer Polytechnic Institute. She joined the Department of Biomedical Engineering at Purdue University in the summer of 2000. Her research interests include cellular and molecular bioengineering, determination and modeling of the mechanical properties of soft tissues, cellular mechanotransduction, and tissue engineering. She is also actively involved in novel methods of engineering education, especially those geared towards increasing the percentages of females and minorities in various engineering fields.

Address: 1296 Potter Building, Department of Biomedical Engineering, Purdue University, West Lafayette, IN 47907-1296; telephone: 765-494-2995; fax: 765-494-1193; email: khaberst@ecn.purdue.edu.

THOMAS J. WEBSTER

Dr. Thomas J. Webster is an assistant professor in the Department of Biomedical Engineering at Purdue University. Dr. Webster received his bachelor's degree in 1995 in Chemical Engineering from the University of Pittsburgh. He then continued his education at Rensselaer Polytechnic Institute where he received both his master's (1997) and doctoral (2000) degrees in Biomedical Engineering. He joined the Department of Biomedical Engineering at Purdue University in the summer of 2000. His research interests include the design, synthesis, and evaluation of synthetic nano-structured materials for various implant applications (including bone, neural, cartilage, and vascular). He also enjoys research on exploring novel ways to improve engineering education.

Address: 1296 Potter Building, Department of Biomedical Engineering, Purdue University, West Lafayette, IN 47907-1296; telephone: 765-494-2995; fax: 765-494-1193; e-mail: twebster@ecn.purdue.edu.