

An Immersion Term in Biomedical Mechanics

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Abstract

This paper describes an Immersion Term in Biomedical Mechanics that was developed under a Whitaker Special Opportunities Award. We developed this program between the Sibley School of Mechanical and Aerospace Engineering at Cornell University and the Hospital for Special Surgery (HSS) affiliated with the Weill Medical College of Cornell University. The main goal was to expose Cornell engineering students to research and clinical practice in a hospital setting. The Immersion Terms took place at HSS in New York City. Students from the graduate fields of Mechanical and Biomedical Engineering at the main campus spent either 6 weeks (doctoral students) or 3.5 weeks (masters students) at the hospital. The students participated in orientation, courses on musculoskeletal mechanics, independent studies, observation in the operating room, tours of laboratory research facilities, and multiple seminars and meetings. Based on evaluation forms and exit interviews, the students gained the most from the operating room experiences, the independent study, the musculoskeletal course, and the awareness of what it takes to be full-time hospital research staff. We also initiated a corresponding exchange program for medical doctors in training at HSS to attend the Sibley School of Mechanical and Aerospace Engineering in a masters degree program. To date, one resident in orthopaedic surgery has participated in this program. Based on the overwhelming enthusiasm of the students in both programs, the Immersion Term concept is recommended for maximizing exposure of graduate students in biomedical engineering to hospital-based research and for training physicians in biomedical engineering.

Introduction

The gap between an engineering school and a medical school can be both physical and ideological. The Sibley School of Mechanical and Aerospace Engineering of Cornell University in Ithaca, NY, and the hospitals of the Weill Medical College of Cornell University in New York City face a physical gap that is daunting -- a separation of over 200 miles. Researchers from the two institutions have been working together successfully for over 25 years, and we wanted to strengthen a parallel educational program for graduate students. With assistance from the Whitaker Foundation, we have developed an Immersion Term to span this gap and expose Cornell biomedical engineering students to research and clinical practice in a hospital affiliated

with the Medical College. Our goals were to: 1) create an experience that increases the exposure of engineering graduate students to hospital-based research and practice, 2) tailor the experience to doctoral or masters students, 3) build course notes, 4) develop independent case studies of clinical problems in orthopaedic biomechanics, and 5) obtain constructive feedback from the participants.

General Description of Clinical and Research Programs at HSS

HSS was founded in 1863 and is dedicated to the treatment of clinical problems in orthopaedics and rheumatology. It is a teaching hospital of the Weill Medical College of Cornell University. The hospital has 160 beds and 17 operating rooms. Over 13,000 surgeries are performed each year. Musculoskeletal conditions treated include arthritis and osteoporosis, spine and sports injuries, cerebral palsy, and spina bifida.

Research at HSS includes basic and applied research in orthopaedics, rheumatology, and related scientific disciplines. Researchers at HSS strive to identify the mechanisms underlying musculoskeletal and autoimmune diseases and to discover and develop effective approaches for prevention, diagnosis, and treatment of these disorders. There are six primary areas of research: biomedical mechanics and biomaterials, excitable tissues, immunology, mineralized tissue, soft tissues, outcomes, and clinical research. Supporting these primary areas are common core facilities: analytical microscopy, mechanical testing, infrared imaging, statistics, and others. These cores contain technologically advanced equipment utilized by physicians, scientists, and bioengineers. HSS scientists have received major funding from Federal and non-Federal sources for research programs.

Program Features of the Immersion Term

Students and Advisors

Students were members of the graduate fields of Mechanical and Biomedical Engineering at Cornell University. Doctoral students spent 6 weeks in the HSS Immersion Term over the summer. Masters students spent 3.5 weeks at the start of the spring semester. Enrollment was limited to 3 to 6 students per term so that maximum interaction could be gained in the hospital environment. Housing was provided nearby. The students had two local advisors at HSS, Elizabeth R. Myers, Ph.D., and Timothy M. Wright, Ph.D., of Biomedical Mechanics, and two Cornell advisors, Marjolein van der Meulen, Ph.D., and Donald L. Bartel, Ph.D., of Mechanical and Aerospace Engineering.

Orientation

The first days of the Immersion Term were dedicated to orienting the students to the hospital environment. This meant distributing schedules, departmental information, library information, ID badges, and safety requirements. The students were required to attend a safety meeting given by the HSS Research Administration Office and had to complete tests in radiation safety and biosafety.

Coursework: Soft Tissue Mechanics

A course titled *Mechanics of Soft Tissues* was offered by Dr. Myers for a total of 18 contact hours. This course was designed specifically for the Immersion Term students. Mechanics of articular cartilage, meniscus, intervertebral disc, tendon, and ligament, and tissue engineering topics were covered. Videos and operating room visits were used to expose students to soft tissue diseases and current treatments. The students were required to give an oral presentation at the end of the course in which they reviewed two research papers (a current paper and a classic study) on a significant problem in soft tissue mechanics.

Independent Study: Case Report of Failed Implant

The students were given a retrieved orthopaedic implant (such as a hip prosthesis) during the first week of the term. Each implant had failed while in service in the patient. They then met with Dr. Wright once a week to discuss analysis of the failed implant. They were required to obtain and review radiographs and medical records for the patients. They used laboratory microscopic and photographic techniques to perform physical analyses of the implants. They also performed analytical failure analyses. Each student was required to write a case report and give an oral presentation at the end of the independent study.

Tours of Laboratory Facilities

The students went on tours of the following hospital facilities:

1. Biomedical Mechanics Laboratory
2. Soft Tissue Mechanics Laboratory
3. Infrared Imaging Facility
4. Analytic Microscopy Laboratory
5. Motion Analysis Laboratory
6. Facility for Comparative Studies

During some of the laboratory tours, the students participated in actual experiments. This interactive approach was highly preferred by the students over simple, non-interactive tours.

Clinical Interactions

With the assistance of the orthopaedic residents and attending physicians, the students were able to attend clinical conferences, accompany physicians on surgical rounds, and go into the operating room. The students observed surgeries such as anterior cruciate ligament reconstruction, shoulder hemiarthroplasty, total hip replacement, and total knee replacement. The operating room experiences were rated as the one of the best aspects of the Immersion Term by the students during exit interviews.

Seminars, Research Meetings, and Journal Club

Students were required to attend on-going seminar series and lectures at the hospital. During their stay, they were able to attend research seminars on topics such as Skeletal Development and Growth, Mediation of Bone Adaptation, Authorship of Scientific Manuscripts, and How to

Design a Research Study. In addition, students were asked to attend regular weekly research meetings of the Biomedical Mechanics Laboratory and to participate in the monthly Bone Journal Club. Students were responsible for reviewing articles at the Journal Club, an experience that taught the students how to take a critical approach when reviewing the scientific literature.

Exit Interviews: Feedback from the Students

At the end of the term, the students filled out an evaluation form and then met with Dr. Myers to give constructive feedback. Overall, the students found the program to be extremely useful and informative. Interaction with clinical staff and attendance in the operating room were rated as the greatest learning experience of the program. The students recommended increasing the number of operating room experiences. Also rated very useful were the course on soft tissue mechanics and the independent study. The students found that the independent study made them learn hospital operations (e.g., how to obtain medical records) and medical terminology and jargon, which they thought would be of great benefit in the future. Some of the laboratory tours were scored not very useful, and future Immersion Terms will attempt to make laboratory tours interactive. The greatest endorsement came from the suggestion that the program be made a semester long.

MD/MS Fellowship Program at Sibley School of Mechanical and Aerospace Engineering

We have started a corresponding exchange program for medical doctors in training at HSS to attend the Sibley School of Mechanical and Aerospace Engineering in a masters degree program. The main goal of the MD/MS Fellowship Program is to allow medical students or residents to participate in biomedical engineering curriculum. The program provides graduate level engineering education for medical students or residents who wish to collaborate with biomedical engineers but who do not wish to pursue an MD/PhD. To date, one resident in orthopaedic surgery at the Hospital for Special Surgery has completed the program. He is back operating at the hospital and collaborating effectively in mechanics research.

Summary

Graduate education in biomedical engineering must include exposure to medical research, but it can be difficult to guarantee such experience. By integrating graduate students completely into the hospital clinical and research environment for an intense time period, exposure to the workings of hospital-based medical research is guaranteed. The Immersion Term concept is recommended for maximizing exposure of students in biomedical engineering to hospital-based research and operations.

BIOGRAPHICAL INFORMATION

ELIZABETH R. MYERS

Elizabeth R. Myers is Associate Professor of Applied Biomechanics at Weill Medical College of Cornell University, Associate Scientist at the Hospital for Special Surgery, and Visiting Professor at the Harvard/MIT Division of

Health Sciences and Technology. Dr. Myers received a B.S. degree in biology from Duke University and a Ph.D. in Mechanical Engineering from Rensselaer Polytechnic Institute.

MARJOLEIN C. H. VAN DER MEULEN

Marjolein C. H. van der Meulen is an Assistant Professor of Mechanical and Aerospace Engineering at Cornell University and an Assistant Scientist at the Hospital for Special Surgery. Dr. van der Meulen received her S.B. from the Massachusetts Institute of Technology, a M.S. and Ph.D. from Stanford University, all in mechanical engineering.

TIMOTHY M. WRIGHT

Timothy M. Wright is Professor of Applied Biomechanics at Weill Medical College of Cornell University and Director of Biomedical Mechanics and Senior Scientist at the Hospital for Special Surgery. Dr. Wright received his B.S. degree from Lehigh and M.S. and Ph.D. degrees from Stanford University.

DONALD L. BARTEL

Donald L. Bartel is Professor of Mechanical and Aerospace Engineering at Cornell University and Senior Scientist at the Hospital for Special Surgery. He received B.S. and M.S. degrees from University of Illinois and Ph.D. from University of Iowa.