Biomedical Engineering and Bioengineering: Accomplishments by People Who Are Deaf or Hard of Hearing

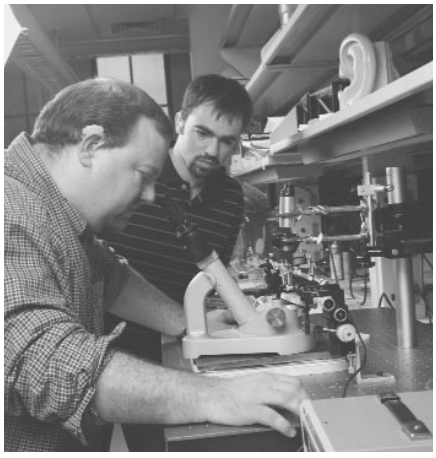
by Robert M. Raphael, Ph.D., and J. Tilak Ratnanather, D.Phil.

Robert M. Raphael, Ph.D., who is hard of hearing, is an assistant professor in Bioengineering at Rice University, and J. Tilak Ratnanather, D.Phil., who happens to be deaf, is an assistant research professor in Biomedical Engineering at Johns Hopkins University. They are excited about the increasing number of undergraduates who are deaf or hard of hearing and are majoring in this field and have personally mentored several of these students.

In Spring 2003, at least three undergraduates who are deaf or hard of hearing will earn bachelor's degrees in Biomedical Engineering (BME) or Bioengineering. These include Kelly Halacka at Case Western Reserve University, Nathan Spencer at Rice University, and Matt Browne at University of California at San Diego. Later this year, a graduate student at Johns Hopkins University, Lina Reiss, will become the first person who is deaf to defend a doctoral dissertation in BME. With all these graduations, there is some concern about the future, but the ranks of the deaf and hard of hearing in bioengineering will be replenished by Dominic Pisano, Brian Kelly, and Tim Brandau, who are majoring in BME or Bioengineering at Johns Hopkins University, Syracuse University, and University of Iowa, respectively.

Kelly Halacka, a Michigan native, will graduate with a concentration in Biomechanics with a minor in English. She likes to write as well as solve free-body diagrams. Profoundly deaf like her two siblings, she has spent extended periods in Houston, TX, completing a cooperative internship with NASA's Johnson Space Center via the American Association for the Advancement of Science's ENTRY POINT! program. She plans to attend graduate school to earn a master's degree in Biomechanical Engineering.

Born and raised in Portland, OR, Nathan Spencer was diagnosed with severe deafness when he was 18 months old and later attended Tucker-Maxon Oral School. During his junior year at Rice University, he met Raphael and became fascinated by both the complexity and the function of the auditory system. After a year of undergraduate research with Raphael, he spent a summer with Peter Steyger, Ph.D., who is hard of hearing and an assistant professor of otolaryngology – head and neck surgery at Oregon Health and Science University (OHSU). Spencer visualized the distribution of various carbohydrates in cochlear structures via lectin (a plant-derived protein) binding and confocal microscopy in Steyger's lab. He also presented a poster at the midwinter meeting of the Association for Research in Otolaryngology in February 2003. Spencer is conducting targeted drug delivery and micromechanical experiments in Raphael's lab using the enhanced knowledge of the structures in the cochlea. He aspires to become a physician/scientist specializing in otolaryngology. Given his recent participation in a National Deaf Leadership Council in Washington, DC, Spencer is certain to become a strong advocate for the deaf in science.



Robert Raphael and Nathan Spencer from Rice University, Tommy LaVergne/Rice Univertity.

Matt Browne, born and raised in Anaheim, CA, has been profoundly deaf from birth, and received the Nucleus® 24 implant in 1997. Matt spent two summers writing software to manipulate magnetic resonance imaging (MRI) data for Ratnanather as part of a National Science Foundation-sponsored Research Experiences for Undergraduates (REU) program. At Cochlear Corporation in Sydney, Australia, last summer he wrote a headset-testing program in Labview and offered his experiences as a user to other engineers. (Matt also played the baritone in his high school band at the opening ceremony of the 2000 Olympic Games in Sydney.)

So what is so special about BME and Bioengineering? It is an interdisciplinary field that utilizes engineering skills in solving biological problems that have the potential to improve the detection and treatment of diseases. In particular, BME has been responsible for medical advances such as cochlear implants, digital hearing aids, defibril-

lators, and CAT and PET scans. The past few decades have seen BME and Bioengineering become established engineering majors at colleges with the number of undergraduates doubling in the 1990s. BME can be considered as a "hot" major in the dawn of the "Biotechnological Century." So it is not surprising to see people who are deaf or hard of hearing attracted to an increasingly popular academic major that has the potential to affect so many. Nathan Spencer remarked, "I think it's important for Bioengineering/BME to have people with disabilities because the whole aim of Bioengineering/BME is to advance healthcare, and we know first hand the importance of these advancements in our own lives. In addition, for me, there's always been an element of accomplishment in succeeding despite of the disability. I'd bet this is true of others as well and would be an asset to the field of Bioengineering/BME."

Dominic Pisano, who became postlingually deafened due to hereditary deafness, was educated in the mainstream and was one of the top high school soccer players in Ohio. After meeting Ratnanather during an Open Day visit to Johns Hopkins University, he switched majors to BME. Pisano looks forward to the day when neurosurgeons who are deaf can work in the operating room via remote captioning displays on their wrists. In his first semester, Dominic has familiarized himself with imaging software by making an interactive movie. Dominic also has just been drafted into the USA Deaf Soccer Squad and is preparing for the Deaflympics in 2005. He also helped to recruit yet another student who is deaf or hard of hearing who hopes to enter the BME undergraduate program in Fall 2003.

At age 3, Tim Brandau was the first child in Iowa to receive a cochlear implant. He is very thankful to the Biomedical Engineering industry for his implant. Tim wants to learn skills that will enable him to further advance biomedical technology so that he may help others as he has been helped. As a freshman, he plays the saxophone in the University of Iowa Hawkeye Marching Band, thus establishing a rivalry with his older brother at Iowa State University.

Dr. J. Tilak Ratnanather, assistant research professor in the Department of Biomedical Engineering at Johns Hopkins University, and Lina Reiss, a doctoral student in biomedical engineering, look on as Dominic Pisano, a freshman biomedical engineering major, displays MRI scans of reconstructed brain surfaces. Will Kirk/Johns Hopkins University.

An Annapolis, MD, native, Brian Kelly has been deaf since birth, but was misdiagnosed until age 2, when he received hearing aids. Later, when he was 7, he received his first cochlear implant, the Nucleus® 22 in 1990, one day after the Food and Drug Administration approved the CI for children. About 10 years later (2000), he received another cochlear implant, the Nucleus® 24, in his other ear. He is currently spending his sophomore winter break at the House Ear Institute studying noise in cochlear implants. At the Syracuse Institute for Sensory Research, he developed software to study how the brain detects the presence of noise. This research has been mentioned in *Syracuse University Magazine.*

The auditory research that is performed in many BME departments may be one of the areas attracting people who are deaf or hard of hearing. For example, at Johns Hopkins University School of Medicine, the Center for Hearing Sciences has a close relationship with BME. They received postdoctoral training in this program, where Reiss is finishing her graduate work. The academic backgrounds of Raphael, Ratnanather, and Reiss exemplify the multidisciplinary nature of BME. Raphael has a bachelor's in Physics from University of Notre Dame and a Ph.D. in Biophysics from the University of Rochester, Ratnanather has a Ph.D. in Mathematics from the University of Oxford, and Reiss has a bachelor's in Mechanical Engineering from Princeton University. Research in auditory sciences has also attracted other deaf people such as: Henry Adler, who is doing postdoctoral research on cochlear outer hair cells at the National Institute on Deafness and Other Communication Disorders at the National Institues of Health; John Brigande, who will start as Assistant Professor of Otolaryngology–Head & Neck Surgery at OHSU this summer after completing postdoctoral research on the morphological development of the cochlea at Purdue University, and Ray Goldsworthy, who is currently doing doctoral research in noise reduction in cochlear implants in the

Harvard–Massachusetts Institute of Technology Speech and Hearing Program.

Biomedical engineers must be competent in chemical, physical, mathematical and computer sciences as well as the life sciences and engineering. They must learn to work alongside physicians and biologists and apply engineering skills to solve biomedical and biological problems at the body, organ, organelle, cellular, and molecular levels. BME historically started with an emphasis in instrumentation and medical imaging and now has expanded into the realms of computational biology, biomaterials, molecular and cellular bioengineering and tissue engineering.

The recent establishment of BME undergraduate programs at several universities is due in part to generous financial support from the Whitaker Foundation (www.whitaker.org). An integrative philosophy of BME education has now begun to emerge. This means that courses have to be designed such that traditional engineering skills are taught in a medical or biological context. Ratnanather is working with a couple of undergraduates on an interactive web course in biomedical imaging that is targeted at physicians and life scientists who will be using image analysis software developed at Johns Hopkins University. At Rice University, Raphael has developed a thermodynamics course unique to bioengineering students as well as introducing a new course in sensory neuroengineering that covers the auditory system. These core courses provide the undergraduates the necessary interdisciplinary skills to solve challenging problems in teams.

The interdisciplinary nature of BME permits the student to choose a concentration in a traditional engineering discipline. The choice is up to the interests and career goals of the student. An aspiring neurosurgeon could consider mechanical engineering to learn how to develop methods for robotic surgery or computer science to develop software to minimize surgical errors. Design projects give students a chance to integrate traditional engineering skills and solve a biological problem. As Brian Kelly says, "There are endless opportunities in biomedical engineering. I hope I can develop and manufacture medical devices in the future as well as develop some biomaterials that stick to each other while safe to use in MRI (such as cochlear implants). Also, I love to study mechanics. That's why I chose the path comparable to mechanical engineering."

According to Reiss, it is evident that BME benefits people who have demonstrated that they can achieve a good deal despite their hearing loss and contribute something unique toward helping others. No doubt influenced by the subdiscipline of auditory research, BME has welcomed the contributions of the deaf and hard of hearing and has been accommodating in providing necessary assisting services such as remote captioning.

The biomedical engineering industry is expected to become an important and critical component of health care delivery, resulting in an increased demand for trained biomedical engineers who will be in a position to make substantial contributions to the well being of mankind. Students who are deaf or hard of hearing are encouraged to consider BME as either an undergraduate major or a graduate major especially in light of substantial federal funds and industrial internships that will support students from underrepresented communities in biomedical research.

Drs. Raphael and Ratnanather dedicate this article to Murray B. Sachs, Ph.D., Massey Director of BME, Johns Hopkins University, whose outstanding leadership in BME education and research in the auditory system attracted people who are deaf or hard of hearing to Johns Hopkins University.

RESOURCES

See http://coop.jsc.nasa.gov/biography/bios/halackak.htm and also *Volta Voices* Nov/Dec 2002 issue.