The BioTECH

MIT Biomedical Engineering Society Newsletter Vol. I, Issue 2, April 2003

President's Column - Amy Shi, Course 10, 2004

Full Circle

"I have the following vision for the future of BMES…please give me the opportunity to turn this vision into reality." With a blink of an eye, a full year has passed since that day last May when I took on the role of Chapter President. Some of you know my story. Many of you don't.

It all started one lazy summer day after freshmen year. I was working in lab when I turned to the guy working in the bench next to me and asked him, "So what is BMES?" He was then the president of the newly re-activated MIT Biomedical Engineering Society. Little did I know that this fateful four-word question would turn into an hour-long conversation that blossomed into two fulfilling years of service. From Industrial Relations Officer to President, I have had the joy to see BMES grow from a barely surviving, ASA de-recognized student association to one of the leading BMES chapters in the country. I started out my first year organizing site tours of Genzyme and Johnson & Johnson, inviting companies to speak, and opening up the world of industry to our students. Then in the spring, I was elected to the position of Chapter President, giving me the opportunity to work with a group of innovative Executive Board members and faculty advisors to further shape the future of BMES. This second year has been an especially fulfilling one, bringing with it many new and exciting changes.

The beginning of this year was signified by the inaugural lecture for the BMES-EMBS Distinguished Lecture Series. One week later our first member's meeting attracted so many of you that only standing room was left in the Building 56 classroom. That meeting demonstrated the enthusiasm of our members to the BMES Executive Board, and motivated us to work hard to bring every opportunity possible to you and the rest of the undergraduate community. From industrial site tours to company presentations, from the six BMES-Johnson & Johnson Biomedical Engineering Research Prizes, to the new quarterly BMES newsletter, The BioTECH, this year has been a year of beginnings as well as a year of growth. We have accomplished many of our goals, and there are many more in front of us, waiting to be discovered.

Looking back on these past two year, I have been reminded of how lucky I am not only to be part of it all, but also to have had the experience of leading the conversion of our visions into reality. None of this would have been possible without the dedication of the BMES officers, the encouragement of our faculty advisors, and the enthusiasm of the BMES members. We look to next year, which brings with it a new group of officers, new ideas, and new visions. May the foundation from these past two years be strengthened and enriched in the years to come. Let the legacy continue.

Editorial

Pia Banerjee
Guest Writer
Course 7,
2005

Helping the Blind to See - The Bionic Eye

Curing blindness may sound impossible, but with the miracles of artificial intelligence, the blind are seeing and believing.

The bionic eye, made popular by "The Six Million Dollar Man", is no longer just a work of fiction. After nearly 50 years of artificial intelligence research, three major companies have invented "bionic eyes" that grant limited vision to the blind. The Dobelle Institute's design looks like a complicated pair of sunglasses that invasively inserts into the skull, while NASA and Optobionic's designs involve retinal replacements.

AN INVASIVE CAMERA

Steven Kotler, the first viewer of the Dobelle invasive camera design, expresses shock and amazement toward seeing a bionic eye attached to the blind patient. He declares, "All I can do is stare. The

Cont. on page 2

In This Issue

Interview Prof. Sherley….3
J&J Award Winners…….4
Summer Jobs……..…….7

The BioTECH

BioMedical Engineering Society Newsetter
Volume I, Issue 2

Editor
Alexis DeSieno 2005

BioTECH Staff in this Issue
Meiling Gao 2005
Kelley Rivoire 2005
Judy Yeh 2005

Guest Writers in this Issue
Pia Banerjee 2005
Amy Meadows 2003

Wanna write for the BioTECH? Comments about the BioTECH? Email: alexisd@mit.edu

If you would like more information about BMES, go to http://web.mit.edu/bmes/

The BioTECH is published quarterly by the BMES and BioTech staff. The BioTECH welcomes letters to the Editor.

Officer Report

Vice President of Special Programs

Audrey Wang, Course 7, 2003

The 2002-2003 EMBS-BMES Distinguished Lecture Series is continuing with great success! A big thanks to all BMES members who have helped me poster and set up for these lectures -
I couldn't have done it without you!

Since our last issue of the BioTECH, we have had two more exciting lectures expertly given by Dr. Linda Griffith (Professor of Chemical and Biological Engineering here at MIT, as well as faculty advisor for the MIT Student chapter of BMES) and Dr. Vasilis Ntziachristos (Assistant Professor and director of the Laboratory for Bio-optics and Molecular Imaging at the Center for Molecular Imaging Research with adjunct appointments at the Massachusetts General Hospital and Harvard Medical School).

In March, Professor Griffith spoke about "Tissue Engineering - From the Bench to the Bedside and Back" and described the micro fabricated bioreactor developed by her team at MIT as well as the application of this system to analyze the efficacy and toxicity of gene therapy vectors, to assess drug metabolism, and evaluate responses to environmental toxins. Dr. Ntziachristos introduced the uses and capabilities of Fluorescence Molecular Tomography (FMT) in his talk entitled "Bringing in-vitro Assays to Life with FMT" in April.

We invite you to join us for our last lecture of the semester on **Wednesday, May 14, 2003 in Room 6-120 at 7PM**. Dr. R. Rox Anderson, an Associate Professor of dermatology at Harvard Medical School and director for research of the Laser Center at Massachusetts General Hospital, will be speaking about **Optical Targeting Strategies for Biomedical Problems.** Light refreshments will be served at 6:30PM. This event is free and open to the public, so everyone is welcome!

If you have any questions or suggestions, please contact Audrey Wang (audreyw@mit.edu). We look forward to seeing you!

Bionic Eye- Ccnt. From 1

man has computer jacks sunk into both sides of his skull."

There are three parts to the Dobelle system. A tiny video camera supported by a pair of sunglasses takes pictures of the patient's surroundings. A mini-processor translates the pictures into a signal that the brain can interpret. Then comes the most amazing part of the system: brain implants. Wires run from the sunglasses and processor, around the patient's head, and directly into the sides of the patient's skull. The wires connect to the visual cortex of the brain, which analyzes the pictures taken by the video camera. This may result to be a problematic design should something cause the wires to unhook themselves from the patient's brain.

ARTIFICIAL RETINAS

NASA's system was developed on the space shuttle

Cont. on 6

Interview with Professor Sherley -the New BMES Advisor

By Meiling Gao, Course 3, 2005

Could you tell me a little about yourself?
I've been at MIT for 5 years. Before that, I was at Fox Chase Cancer Center in Philadelphia for 7 years. I did research on translational cancer research.

What made you decide to come to MIT?
I found the BE program here particularly attractive. I did research at Fox Chase but I've always been interested in applied research where I would be able to apply what I discovered in the near future rather than let's say, the next 50 years. My MD/PhD has allowed me to be multidisciplinary and I can really continue that here.

What types of research are you involved in now?
If you asked people in my lab, they would say stem cell research. It's really an outgrowth of my interest in cancer research.

How do you feel about being the new advisor for BMES?
Professor Griffith nominated me. We have always worked closely but she's just been so swamped with other obligations that she asked me to be BMES's advisor. Actually, there are two advisors. Matt Lang, who is an excellent person for the job, is an assistant professor in Course 2 and is the other professor. Even though there might be a "primary advisor" title in front of my name, Matt and I will be working closely in this dual approach to help BMES.

What role do you see yourself playing as the new advisor?
I initially felt that I wouldn't be qualified to the job. I have the medical background but not the engineering one. Linda, however, assured me I would be fine.

Do you see it being long term?
<laughs> Actually, I've been asking myself that. I'll be advisor until the time comes along when it seems appropriate for me to pass the position to someone else.

What are your thoughts on BME and BE not being majors?
They will be in the future. <laughs> I think we're on a verge of the growth of a new trend in science where biology and engineering are coming together and I think it's wonderful! BME has been around for a while. I think bioengineering and BME both fall under the larger category of Biological Engineering (BE). Bioengineering is using biology as a substrate for engineering such as using neurons to build a device while BME is designing devices to be used in the medical fields. BE is making discoveries in research using engineering principles.

Do you have any advice for students who are interested in BME or BE?
Whenever you see a meeting for BMES, GO! It's one of the best ways to access useful information straight from the students themselves. Go to those meetings, open houses, and talk to professors.

Anything else you would like to say to BMES members and students?
I'm really really excited about being the new advisor and can't wait to interact with the students!

Beyond "Use It or Lose It"- *Guest writer*

Amy Meadows, Course 9, 2003

Christopher Reeve, the 50-year-old "Superman" act, was paralyzed from the neck down in a fall from a horse seven years ago. As he began to speak out for more funding in spinal cord repair, many experts in the field contended that even if we could regenerate the spinal cord after injury, the brain would have reorganized, leaving someone functionally paralyzed. If the sensorimotor areas of the brain are not used, they will atrophy. In other words, "use it or lose it."

New findings reported by researchers at Washington University in St. Louis, however, are challenging this finding. First, doctors reported that Reeve had recovered some mobility, such as the ability to wiggle his fingers. Now, magnetic resonance imaging (MRI) of Reeve's brain shows normal activity in the sensorimotor regions. The MRI was virtually identical to that of a 23-year-old doing the same simple tasks, like following the movement of a ball on a screen with his index finger.

Since these findings have just been on one patient, Reeve, doctors have not come to any conclusions about the generalizability. Still, neurologists are encouraged that there are signs that future work in spinal cord regeneration may be able to help thousands of paralyzed people in the United States and elsewhere.

Based on an article on cnn.com "Paralyzed Christopher Reeve makes slight gains."

Spotlight on J&J Excellence in Biomedical Engineering Prize Winners

Adapted by Nancy Benedetti '05 from each student's paper

The 2003 BMES Johnson&Johnson Excellence in Biomedical Engineering Prize Winners. *(left to right)* Geoffrey von Maltzahn '03, Kristen Brodie '03, Tim Fofonoff '03 S.M., Jason Kelly '03, Timothy Lu '03, Jonathan King '04.

Kristen Brodie, Course 3, 2003
Supervisor: Professor C. Ortiz
Nanomechanical Properties of Poly(vinyl choloride)-Based Endotracheal Tubes to obtain New Biomaterials Design principles

The endotracheal tube is a polymeric conduit between the lungs and a ventilator and forms a closed system necessary to maintain optimal respiration in critically ill patients. While speaking with a family friend and retired surgeon, Kristin learned about the clinical problems with current endotracheal tubes, including laryngeal edema, severe morbidity, and occasional death. Realizing that she could make a significant contribution to the medical field by developing a better endotracheal tube, Kristen has been working independently on this project, which was soley her idea.

To date, Kristin has completed a comprehensive characterization study of the mechanical, chemical, microstructural, and biocompatibility properties of the currently used endotracheal tubes. Kristin's plans for the future of the project include investigating polymeric materials for their potential use in the design and creation of a novel endotracheal tube and designing a new low-pressure inflatable tracheal cuff.

Tim Fofonoff, Course 2, 2003 S.M.
Supervisor: Professor Ian Hunter
New Methods for Fabricating Brain-Machine Interfaces

A brain-machine interface (BMI), which links the cerebral cortex to the outside world has the potential to restore lost neurological functions associated with degenerative muscular diseases, stroke, or spinal cord injury. In order to obtain the resolution required to move output BMI, direct BMI is needed to simultaneously intracortically record from several individual neurons.

Tim was responsible for the design and fabrication of a microelectrode array assembly for a surgically implantable wireless device used for motor cortex studies in nonhuman primates. Because his Telemetric Electrode Array System was very successful at recording neural activity in nonhuman primates, Tim wrote and presented two conference papers, one for the IEEE EMBS special topic conference on microtechnologies and the other for the annual EMBS-BMES joint conference. He is currently writing a journal article based on his research. Tim was also listed as co-inventor in a filed patent application that was largely based on his research.

Jason Kelly, Courses 7/10 2003
Supervisor: Professor Douglas Lauffenburger
Multivariant Analysis Techniques as Tools for Relating Intracellular Signaling to Cell Behavior

With the emergence of new technologies for the characterization and quantification of biological processes, there is a great need for methods of data analysis to organize and interpret large data sets. Jason developed and applied a principle components analysis (PCA) and a partial least squares (PLS) approach to study the complex network of signaling molecules in the cytokine-induced death versus survival apoptotic decision process in human colon adenocarcinoma cells. These bioinformatics methods utilize complex matrices and reduction of dimensionality by selection of principal components.

Cont. on 5

Spotlight on J&J Excellence in Biomedical Engineering Prize Winners

Cont. from 4

The results of Jason's project show how PCA analysis can, without prior knowledge, generate a model, which classifies samples by their most prominent variations and disregards experimental noise. Furthermore, these data may be correlated with phenotypic outcomes through PLS analysis to yield quantitative measurement of the associations between intracellular signaling metrics (activity, level, etc.) and resulting cellular outputs. Jason will be co-author of a bioinformatics journal article currently being written by his research team.

Timothy Lu, Course 6, 2003
Supervisor: Professor Rahul Sarpeshkar
Bionic Ears (Cochlear Implants) and the Biophysics of Outer Hair Cells

The development of bionic ears (BE) has been successful in restoring hearing to the deaf by stimulating the auditory nerve with implanted electrodes to simulate the natural response of the ear to sounds. In order to allow for full implantation, the power consumption of signal processors in bionic ears must be cut drastically.

Tim integrated various chips created by researchers in the Analog VLSI (Very Large Scale Integration) and Biological Systems Group to build a channel that will soon be the world's lowest power cochlear-implant processor. Using VLSI CAD software, Tim sent out a VLSI chip for fabrication, and the first iteration worked superbly, consuming only 7.8 μW of power with an internal dynamic range of 51 dB and 64 discriminable levels of loudness. Tim is first author of a paper on micropower single channel BE implants accepted for publication by the 2003 International Symposium on Circuits and Systems.

Jonathan King, Course 7, 2004
Supervisor: James Sherley
Expansion of Murine Hair Follicle Stem Cells by the Suppression of Asymmetric Cell Kinetics

Hair follicle stem cells have been shown to possess the capacity to differentiate into epidermis and all of its accessories, including hair. The potential medical benefits of growing a complete epidermis from stem cells include skin regeneration in burn victims and hair regeneration in male-patterned baldness.

Jonathan applied suppression of asymmetric cell kinetics (SACK), developed in Professor Sherley's lab, to coax hair follicle stem cells to give rise to two identical stem cells instead of giving rise to one stem cell and one progenitor cell. This prevents stem cell dilution by transient amplifying cells and allows for the establishment of pure culture stem cells. As a result of his SACK work, Jonathan has established several cell lines presumably containing stem cells, and applied limited dilution cloning to generate a clonal cell line.

In the next phase of his research, Jonathan will be testing the regenerative capacity of the cell line with *in vivo* experiments in a murine wound repair model. These experiments will test the cell line's ability to differentiate into all the necessary components of the mouse's skin including epidermis, hair, and sebaceous glands.

Geoffrey von Maltzahn, Course 10, 2003
Supervisor: Dr. Shuguang Zhang
Positively-Charged Surfactant-like Peptides Self-assemble into Nanostructures

Cationic surfactant peptides represent a novel material with a wide range of potential applications, ranging from traditional surfactant areas (detergents, cosmetics, drag reduction) to new applications as carriers for encapsulation and delivery of small water-insoluble molecules and large biological molecular systems, including negatively charged nucleic acids.

Geoffrey has developed a class of cationic surfactant peptides that self-assemble into nanotubes and nanovesicles as determined by dynamic light scattering (DLS) and Quick-Freeze/Deep Etch Cryo-TEM (Transmission Electron Microscopy). These peptides were designed to mimic cationic lipid molecules, and have a hydrophilic head group consisting of one or two positively charged amino acids and a tail of six hydrophobic amino acids.

This new type of molecularly engineered surfactant peptides can form a complex with DNA, and deliver the nucleic acid into tissue cells, making the nanotubes and nanovesicles potential gene delivery vehicles. Geoffrey's work has been accepted for publication as a cover article in Langmuir, and he has been invited to represent MIT and present his research to the US Congress

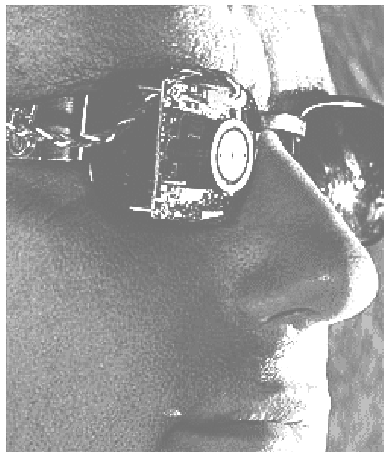
Cont. from 2

Columbia, and this design consists of 100,000 ceramic detectors that function as an artificial retina. Experiments with silicon detectors conducted at MIT and Johns Hopkins University resulted in damage to the eye, which is why ceramic was the used in NASA's experiments instead of silicon. The artificial retina is surgically inserted behind the patient's actual retina, and it acts to replace the rods and cones in the malfunctioning retina. Extending this research one step beyond NASA's work, the Office of Naval Research is trying to develop a chip to replace all the nerve centers in the retina.

Optobionics has also created artificial retinas, and it is currently conducting human experiments. The aim of this artificial retinal implantation is that the implanted retina will stimulate the optical cells around it to function again. Each artificial retina is covered in 5,000 solar cells and contains an electrode to convert light energy into electric impulses for stimulation of the cells around it.

HUMAN TESTING

A few months ago, the retinas developed by Optobionics were placed into 6 patients who suffered from retinitis pigmentosa, and had become close to, if not completely, blind. The results of the experiment weren't perfect, but they were better than any other artificial vision technology to date. Of those who had gone completely blind, all of them gained the ability to distinguish light from dark and make out blurry outlines of objects. Miraculous improvements occurred in the vision of blind patients who had originally been able sense light. After retinal implantation, these people were able to distinguish shapes and recognize faces. One patient saw his wife's face after the first time in years. Another was shocked to see how much he had aged since becoming blind 10 years ago. None of the patients felt pain or discomfort, and none experienced rejection of the retina or became infected.



Man with Dobelle system— Wires connected to the visual cortex of the brain analyze pictures received from a video camera attached to sunglasses that takes pictures of the patient's surroundings. Photo from www.dobelle.com/wired.html

PROBLEMS AND CONCLUSIONS

All of these bionic eye designs give hope of curing blindness in the near future. However, there is much work left to do, as there are still a few problems with all of these developments and test procedures. My main concern is that no control was used in the Optobionics human test. A complete experiment should involve the insertion of nonfunctional retina.

Another major problem with these studies is often barely glossed upon. None of the bionic eyes can help those who were blind from birth or became blind during childhood. All of the artificial eyes simply fix the eye itself; all require the visual cortex, the part of the brain responsible for sight, to be fully functioning. If someone had been blind for his entire life, the visual cortex would never have matured enough to be capable of processing visual signals. In those who became blind during childhood, the visual cortex probably would not be able to process what the eye sees.

Of the two design ideas, an invasive camera and an artificial retina, I think that the artificial retina has more potential for being used widely as a treatment for blindness. Excluding the obvious problems that could arise from having wires hanging around and in a patient's skull, the idea of pieces of skull being removed permanently does not sound appealing. The risks of brain injury from the surgery are immense. Although retinal surgery is not a simple task either, under most circumstances the biggest problem that could arise from this surgery is a malfunctioning eye. Since the goal is to cure blindness, in my opinion, the risk of hurting an eye of someone who can't see seems significantly more minor than the risk of causing injury to a perfectly functioning brain.

There is a great need for further research in the field of artificial eyes. Research still needs to be done on the treatment of blindness in children and in those who were born blind, and current designs of artificial eyes should be refined. With ongoing research, one day in our lifetimes we will be able to see the miracle of completely restoring sight to the blind.

Still Need a Summer Job? Check out these Opportunities for BMES Students!

Compiled by Judy Yeh, Course 10, 2005

Project: Summer Internship Opportunity in Biotech Industry, Cambridge, MA
Organization: Curis, Inc. Neurodegenerative Disease Research (http://www.curis.com)
Contact: Karen Allendoerfer, Ph. D., Staff Scientist, kallen@curis.com, 617-503-6571

Project will involve testing potential drug candidates for effects on peripheral nerve regeneration and mechanism of action. Student will perform in vivo mouse models of nerve regeneration, histology, immunohistochemistry, and Taqman RT-PCR. Experience working with rodents and basic knowledge of molecular biology a plus.

Preferred specializations: Neuroscience or developmental biology, small animal surgery histology, molecular biology, PCR, Spreadsheets, Statistics (Excel), MS-Office. Education level required: Any is possible, for freshmen and sophomores, a willingness to consider a longer project or returning next summer would be a plus. Interns will be paid at the MIT research rate of $9/hour. Free T-passes will also be available from Curis for commuting purposes. Selected applicants should expect to come to Curis for a 1-hr interview.

Project: Optical Tweezers for Single-Molecule Detection (Summer UROP)
Organization: MIT Media Lab
Contact: Brian Chow, bchow@media.mit.edu

Summer UROP positions are available for students interested in using optical tweezers for detection of biological molecules at the single-molecule level. A strong background in optics, signal processing, and biology is preferred. This research is conducted under the supervision of Professor Joseph Jacobson at the MIT Media Lab, Center for Bits and Atoms. For group information, please visit the group site: (www.media.mit.edu/molecular/).

Project: Delivery of Molecular Medicine to Solid Tumors (Summer UROP)
Organization: HST/Steele Laboratory, Department of Radiation Oncology, MGH
Contact: ricky@steele.mgh.harvard.edu, http://steele.mgh.harvard.edu

The goal of the Steele Laboratory for Tumor Biology (MGH) is to understand the fundamental nature of vascular, interstitial, and cellular barriers to the delivery of molecular medicine to solid tumors, and formulate and test new strategies to overcome and/or to exploit these barriers for improved cancer detection and treatment. The strategies used to accomplish this mission emphasize a strong multidisciplinary approach, integrating the fields of engineering, physics, cellular and molecular biology, and physiology.

Opportunities exist for UROP students to work in this exciting area of cancer research and join our dynamic and diverse research team. Available summer projects include measuring red blood cell velocity in tumor blood vessels and investigating the dynamic changes due to an anti-angiogenic therapy. Faculty Supervisor: Dr. Rakesh Jain.

Project: Cellular Energy Transduction Networks (Summer UROP)
Organization: Whitehead Institute
Contact: Vamsi Mootha, vmootha@genome.wi.mit.edu

A UROP opportunity in the laboratory of Eric Lander is now available for summer 2003. Our group is located at the Whitehead Institute/MIT Center

Cont. on 8

The 2002-2003 EMBS-BMES
Distinguished Lecture Series
presents

~~~~~~

Optical Targeting Strategies for Biomedical Problems

~~~~~~

Dr. R. Rox Anderson
Associate Professor of Dermatology,
Harvard Medical School
& Director for Research,
Laser Center at Massachusetts General Hospital

Wednesday, May 14, 2003
7PM (Refreshments at 6:30PM)
MIT Building 6, 77 Massachusetts Ave., Room 6-120

Cont. from 7

for Genome Research. We are utilizing genomics, proteomics, and computational strategies to decipher cellular energy transduction networks.

Applications of the work include discovering human disease genes as well as drug targets for metabolic syndromes. The successful applicant will have a strong background in biology, have bench science experience in either molecular biology (PCR + cloning) or in protein biochemistry, and be self-directed and motivated.

Project: The Spacercise Curriculum Project (Summer UROP)
Organization: VaNTH Center for Bioengineering Education
Contact: Erika Brown, elb@mit.edu, 617-258-9730

Seeking one full-time summer UROP/student employee for to assist with development of the Spacercise Curriculum Project. The VaNTH Center for Bioengineering Education, in collaboration with the National Science Biomedical Research Institute (NSBRI), is creating a modular curriculum for use in existing high school classes, using issues of astronaut health to excite student about science and engineering.

Specific tasks for a summer hire would include: organization and presentation of space biomedical engineering curricular materials for national distribution; restructuring existing materials to better fit learning sciences framework and national educational standards; evaluation of hands-on and interactive materials for high school anatomy/physiology (as well as some physics and biology) students; development of educational assessment and evaluation tools. Artistic leanings, computer programming skills, and knowledge of basic physiology not required, but are a plus. Employment: $10/hr, 40 hours/week, 10 weeks. Advisor: Prof. Dava Newman, Department of Aeronautics and Astronautics.

Project: Magnetic Resonance Imaging (fMRI) Data Analysis (full-time research assistant)
Organization: VaNTH Engineering Research Center for Bioengineering Educational Tech
Contact: Randy Gollub rgollub@partners.org, 617-724-9602

The goal of this project is to continue development of an interactive web-based tutorial to assist advanced undergraduate and graduate students in learning the fundamentals of statistical analysis of functional magnetic resonance imaging (fMRI) data. The educational design relies heavily on VaNTH (http://www.vanth.org/) learning science principles from the "How People Learn" framework and the STAR Legacy model.

The web based tutorial will use Apache, Java and The Mathworks' WebServer product to permit the end user to access demonstrations utilizing the functionality of Matlab with only a standard web browser. This web-based tutorial is an integral part of HST-583 Functional Magnetic Resonance Imaging: Data Acquisition and Analysis (http://web.mit.edu/hst.583/www) course curriculum. It is used in conjunction with the laboratory portion of the course. If successfully implemented in the web enabled form, this tutorial will be positioned at the user interface of the web portal to the Biomedical Imaging Research Network (BIRN) (http://birn.ncrr.nih.gov/) database allowing immediate and widespread dissemination of this learning tool to the neuroimaging community.

Skills required include MatLab programming, web programming skills especially in Java, some knowledge of Structured Query Language, scripting capabilities, and advanced internal manipulations of database or operating system, and knowledge of C and Java programming languages. Knowledge of XML manipulation a plus. Demonstrated knowledge of a specified operating environment or database management system such as UNIX or Oracle Imaging Interest and some background in neuroscience are favored.

BE Minor
Seniors Award Dinner

Please join Minor Advisors and graduating Students at an Awards Dinner to celebrate your completion of the BE Minor Programs!

Wednesday, May 7, 2003
Rhythm & Spice Caribbean Grill
315 Massachusetts Avenue
5:30-9:30 p.m.

RSVP to Suzette Clinton <sclinton@mit.edu>
By Thursday, May 1, 2003