MIT's Biomedical Engineering Society Newsletter

The BioTECH

Volume 2, Issue 2 December, 2003

Why be Biomedical Engineering (BME)?

By Alexis DeSieno, *BMES PRESIDENT*

In the past two months, I've been asked to do more interviews than I have at any other time in my life except during college admissions. One of the common themes of these interviews is, of course, why the sudden surge of interest by students in the field of biomedical engineering? In my interviews, I've tried to convey a sense for how biomedical engineering is a synergy of many other fields, how recent advances in technology have provided many opportunities in the industry, and how the future can mean anything from medical school, to graduate school, to industry for undergraduates. And I think I've done a pretty good job, as you can tell by the following conversation with a diehard Course 6 and 24 friend (his name changed to protect the innocent):

Iluv6and24: nice interview.
LexiePoo: thank you.
Iluv6and24: you almost lured me into doing BME.

Key word: almost. So why should you be "lured into doing BME?" In the words of Professor Roger Kamm, "Usually, students migrate to bioengineering rather than mechanical, chemical, or electrical engineering because they want to contribute in a more positive way to society. What better way than to improve health care? That's an easy one. But why choose bioengineering rather than a career in medicine, or medical research as a biologist?" His last question is more difficult, and one that I am struggling with myself.

> *"But why choose bioengineering rather than a career in medicine, or medical research as a biologist?"*

As you peruse the rest of this newsletter, particularly the "Conversation with a BE Faculty Member" highlight," the "Course XYZ and BME" feature, and the "Student Research Spotlight" profile, keep this question in mind, and I hope these perspectives will bring to light the irresistible lure that draws so many of us toward BME.

First Two BMES Member Meetings Well-Attended

By Jennifer Fang, *SECRETARY*

For the first BMES meeting, held on September 24, more than 50 students turned out for the program, which began with officer introduction and a statement of chapter mission, continued with Professor Linda Griffith's description of the new Biological Engineering curriculum, and concluded with a company presentation by Cordis, a Johnson & Johnson company. Students signed up for committees such as internship, fundraising, and publicity.

More than 70 people attended the second meeting on October 21 to hear Professor Linda Griffith and Professor Doug Lauffenburger speak on graduate studies in biomedical medical engineering (BME)-related fields. Several graduate programs and the specialty of each were highlighted, such as Johns Hopkins' BME program and its integration with clinical medicine. Many students stayed after the meeting to ask questions and mingle with fellow students and presenters.

Distinguished Lecture Series Drew Crowds

By Mandy Yeung, *VP OF SPECIAL PROGRAMS*

BMES was privileged to have had three very interesting presenters in the 2003-2004 EBMS-BMES Distinguished Lecture Series for September, October, and November. For those who were unable to make the previous lectures, fret no more - one more exciting opportunity awaits in December.

For the month of September, Professor Steven Gullans from Harvard Medical School presented his work at US Genomics on developing technologies that enable single molecule biology using etched silicon devices, microfluidics, and advanced optics. More than 40 people attended this lecture.

In October, Professor James Sherley of Biological Engineering at MIT spoke to more than 60 people about engineering mathematical models to understand and develop adult stem cell expansion. The attendees were very diverse, ranging from undergraduates to professionals in the industry.

Sherley joined the MIT Biological Engineering faculty in 1998, after serving as principal investigator in the division of Medical Science at the Fox

(Continued on page 2)

~ In this Issue ~

Gullans, Sherley, and Smith Spoke at Distinguished Lecture Series

Professor **James Sherley** of Biological Engineering at MIT addressed an audience of more than 60 people from diverse backgrounds at the Distinguished Lecture Series on October 8. Sherley's talk described a biological engineering approach to the problem of adult stem cell expansion.

(Continued from page 1)

Chase Cancer Center in Philadelphia, Pennsylvania. Since joining MIT, Sherley has established a new research program in adult stem cell biological engineering.

In November, Professor Cassandra Smith of Biomedical Engineering at Boston University, presented "Dissecting Complex Diseases: Genomic Instability and Schizophrenia in Twins." Smith spoke on her work to understand the genetic basis of schizophrenia by studying the genetic and genomic differences between identical twins, one of which is schizophrenic. The results from these studies suggest that schizophrenia is associated with a global DNA instability, and that prevention of this disease is through stabilizing the genome.

We are looking forward to hearing from MIT's very own Professor Doug Lauffenburger in December. Lauffenburger is a Whitaker Professor of Biological Engineering, Chemical Engineering, and Biology. As co-director of Biological Engineering and director of the Biotechnology Process Engineering Center, Professor Lauffenburger is involved with defining MIT's newest biology-based engineering discipline, and its applications will impact medicine and human health.

Professor **Cassandra Smith** of Biomedical Engineering at Boston University spoke at the Distinguished Lecture Series on November 19. Smith shared her work on understanding the genetic basis of schizophrenia and its association with global DNA instability.

"The Emerging Biological Engineering Discipline - New Directions and Opportunities" will offer an overview of this new discipline, focusing on novel directions in research, education, and career opportunities being pursued in the MIT Biological Engineering Division.

The EBMS-BMES Distinguished Lecture Series is a monthly event co-sponsored by the Engineering in Medicine and Biology Society (EMBS) of Boston and the Biomedical Engineering Society (BMES) of MIT.

The lecture series is free and open to the public, and we invite you to join us for our next lecture on Wednesday, December 10, at 7 pm in room 66-110. Light refreshments will be served beginning at 6:30 pm, and we encourage you to come network with fellow students, professors, and professionals in the biotech industry over cookies and coffee!

Professor **Steven Gullans** from Harvard Medical School spoke to an audience of more than 40 people at the Distinguished Lecture Series on September 23. Gullan presented his work at US Genomics on developing technologies that enable single molecule biology.

The 2003-2004 EMBS-BMES Distinguished Lecture Series

The Emerging Biological Engineering Discipline—New Directions and Opportunities

Professor Doug Lauffenburger

Wednesday, December 10, 7 pm, Rm. 66-110

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Conversation with a BE Faculty Member

Professor **Matthew Lang** of mechanical and biological engineering shares his perspectives on the new educational options in biomedical engineering at MIT. Lang's research interests lie in elucidating the inner-workings of proteins, enzymes, and biological motors, using instrumentation that combines optical tweezers, single molecule fluorescence, and pulsed spectroscopy.

Interview By Meiling Gao, *EDIOTOR*

The BioTECH: So tell us a little about yourself. Anything really. Hobbies? Interests? Are you a Red Sox fan?

Professor Lang: I enjoy sailing. I guess I've become a Red Sox because two people in my group are fans. I went to the University of Rochester for my undergraduate work where I was a chemistry major. Then I did my PhD at University of Chicago.

BioTECH: So what classes do you teach at MIT?

Lang: I teach BE.310J (Molecular, Cellular, and Tissue Biomechanics) with Professor [Ioannis] Yannas and Professor [Peter] So and 2.672 (Projects Laboratory).

BioTECH: Like most other faculty here at MIT, I'm sure you do research. Could you tell us a little about what you're working on?

Lang: I'm working on single molecules methods, which include single molecule fluorescence. For example, I could use this technique as a reporter of which proteins are present in a sample. I also work on optical tweezers.

BioTECH: So what made you decided to become involved in the Biological Engineering (BE) Department, since you're also part of the Mechanical Engineering Department?

Lang: I actually did my post-doc in biophysics, which is basically building things. I think mechanical engineering is a great way to train people to build, and it was a great fit because the training I received helped with the molecular understanding of topics.

> "When Cordis came to present at our last general meeting, I was extremely surprised at how many of the representatives were mechanical engineers working for a pharmaceutical company."
>
> ***Prof. Matthew Lang***

BioTECH: Do you have any advice for students who are interested in BME, BE, or Course 2A?

Lang: There are many great options in those areas depending on the students' interests and I encourage them to explore all possibilities. For example, [Course] 2A is a great way to go because there's a lot of interest in training students to go into BE. When Cordis came to present at our last general meeting, I was extremely surprised at how many of the representatives were mechanical engineers working for a pharmaceutical company. I think companies are realizing that foundation in different engineering disciplines is an asset to bringing in talent to solve parallel assay problems. The curriculum in Course 2A is miscible with what one wants to get for a BE foundation.

BioTECH: In our last issue, we talked a lot about the new BE major which will be available to the Class of 2009. Any thoughts or comments on that?

Lang: I think this is very exciting. We're making sure we do it right and that students will be trained as best as possible. MIT cares about creating new programs, and I think this new major will definitely strengthen the engineering school, not that it needs any strengthening. I think it will also help bridge different departments. That's one things that's special about MIT; the buildings are connected, and there's interaction between engineering and science.

BioTECH: How do you enjoy your role as associate advisor of BMES?

Lang: I like it. It's really fun and I'm amazed at how much I learn. You get to know one major perspective of the MIT student through class. Through UROPs, you get to see another perspective where the students are really involved in research, which is not necessarily true at some other institutions. Being the advisor for the BMES has shown me that MIT students are very on the ball, organized, and have lots of great ideas and energy. This is really exciting!

Biosketch of Prof. Matthew Lang

Education/Research History
B.S. University of Rochester
Ph.D. University of Chicago
Post-Doctoral Fellowship at U.C. Berkeley, Princeton, and Stanford

Teaching Interests
BE.310J Molecular, Cellular, and Tissue Mechanics
2.672 Projects Laboratory

Research Interests
Biomechanics, Biological Motors, Protein Interactions, Optical Tweezers, Single Molecule Fluorescence, Mechanotransduction

Interested in joining BMES?

Become a member by emailing bmes-request@mit.edu

Interested in writing for The BioTECH?

Email us at TheBioTECH@mit.edu for more information

Course 'XYZ' and BME

A Breadth of Opportunities

The MIT School of Engineering has pioneered an expansion and redefinition of "Bio/Medical" Engineering, and now has over 100 faculty members conducting research and teaching in areas where engineering impacts medicine and biology. The classical focus on engineering applications in medicine ("Medical" Engineering) has a distinguished history at MIT, and remains vibrant with current course offerings reflecting cutting-edge research in telemedicine, vision enhancement, medical informatics, brain-machine interfaces, device design, and many other areas as part of the curricula of several departments.

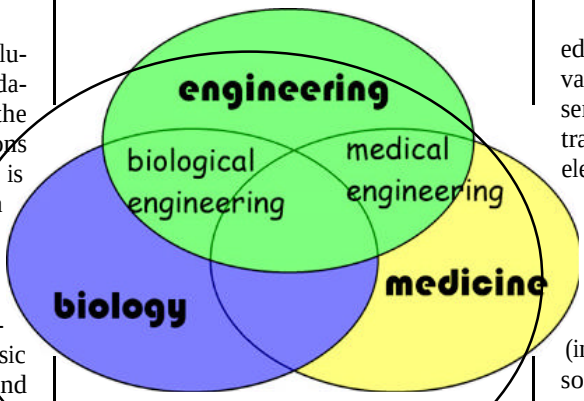
The molecular and genomic revolutions in biology place it as a new foundational science for engineering, joining the well-established engineering foundations of physics, chemistry and math. MIT is an international leader in forging a disciplinary connection with biology – "Biological" Engineering — that has applications ranging from biotechnology to medicine and electronic materials. As with other revolutions in basic science, engineering analysis, design, and synthesis are needed to translate breakthrough discoveries into products and create new industries.

Biological applications are integrated into the core curricula of most MIT engineering departments, and are the entire focus of the Biological Engineering Division (BE). BE was created in 1998 to foster development of innovative new degree programs that fuse biology and engineering by bringing engineering faculty together with biology faculty in one academic unit that is seamlessly integrated with departments.

I: Civil & Env. Engineering

The 1E major includes several core subjects that couple biological processes with analytical and engineering skills to address crucial human-environment interactions. Selection of additional biology subjects and electives allows students to focus on human health issues, premed, or ecology.

What major should I pursue to study biomedical engineering (BME)? This is one of the most common questions students ask of faculty members as well as fellow BME students. Here are some undergraduate degree programs offered by the MIT School of Engineering, showing the breadth of opportunities and the interdisciplinary nature of this ever evolving field.



This information was compiled from the Bio/Medical Engineering brochure developed by the Biological Engineering (BE) Division.

UG B/ME Subjects: 1. 018, 1.080, 1.081, 1.096, 1.107

Contact: Prof. Penny Chisholm

II: Mechanical Engineering

The accredited 2A option allows students to build a custom program combining departmental subjects in biomedical device design; molecular, cell and tissue biomechanics; biological imaging, and others with biology or physiology subjects for careers in medical devices, diagnostics, and drug discovery.

UG B/ME Subjects: 2.772, 2.797, 2.782, 2785, 2.79

Contact: Prof. Peter So

III: Materials Science & Eng.

The newly revised curriculum infuses state-of-the-art examples of materials in medicine and includes biomaterials chemistry as a core subject; students desiring further in-depth study may choose as restricted electives subjects in biomedical materials, biomaterial nanomechanics, and various graduate offerings.

UG B/ME Subjects: 3.051, 3.052, 3.034, 3.96, 3.961, 3.97

Contact: Prof. Anne Mayes

VI: Electrical Engineering & Computer Science

EECS students can customize their educational programs by choosing advanced subjects during their junior and senior years from 7 engineering concentrations: 3 in EE, 3 in CS, and 1 in Bioelectrical Engineering, which includes engineering systems approaches to the study of biological molecules, cells, tissues, organs, and organisms. It also includes applications of signal and image processing to living systems (include speech and hearing), biosensors, biomedical devices, and medical computing.

UG B/ME Subjects: 6.021J, 6.022J, 6.024J, 6.801

Contact: Prof. Dennis M. Freeman

X. Chemical Engineering

To complement the exiting Course 10 and Course 10C degree programs, the ChE Department has developed a proposal to offer Course 10B Chemical-Biological Engineering to reflect the increasing biological focus of its educational program. The new degree program includes cell biology, biochemistry, genetics, and molecular biology as foundations for advanced core lab and design subjects on topics such as drug delivery, tissue engineering, and use genetic technology to produce proteins and commodity chemicals .

UG B/ME Subjects: 10.02, 10.28

Contact: Prof. Karen Gleason

Course 'XYZ' and BME

XVI. Aeronautics & Astronautics

Students pursuing either the 16-1 or 16-2 option can minor in biomedical engineering. The humans and automation division has significant overlap with the biomedical engineering discipline. Human factors engineering, physiological control systems, human spaceflight, and bioinstrumentation are emphasized.

UG B/ME Subjects: 16.400, 16.423J
Contact: Prof. Dava Newman

XXII: Nuclear Engineering

Hands-on lab and design experiences allow students to develop a broad understanding of the applications and engineering of low energy nuclear physics and apply these to biomedical problems through a set of restricted electives that can be combined with biology and chemistry subjects to create a program with a biomedical engineering focus.

UG B/ME subjects: 22.01, 22.058
Contact: Prof. Jeffrey Coderre

XIII: Ocean Engineering

A formal degree program incorporating bio/medical engineering into the ocean engineering curriculum has not yet been established, but research opportunities in this field abound. The OE Department has had students working on projects involving fish hydrodynamics, biomimetic robots, a fish model for vascular research, human factors, artificial gills, and the acoustic signatures of fish in the deep ocean.

Overall, Ocean Engineering has many, varied, and interesting connections to biology and bio/medical engineering, and student participation in any of these aspects is strongly encouraged.

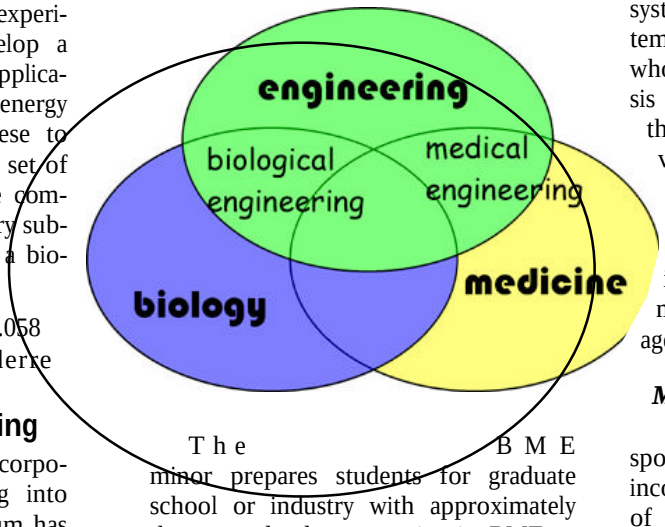
Contact: Dr. Thomas Consi

On the Horizon

A curriculum for a SB degree in Biological Engineering is in advanced stages of development. Many of the core subjects are being offered as part of the BME minor. The SB is not available to students entering in Fall, 2003.

BME Minor

The Biomedical Engineering (BME) Minor Degree is an interdepartmental program comprising 4 subjects in BME - 2 core subjects and 2 electives. These subjects require substantial preparation in science and engineering, and thus the minor is structured in the form of a Science Core (2 courses) and an Engineering Core (2 courses) that serve as prerequisites for the BME courses.



The BME minor prepares students for graduate school or industry with approximately the same depth as a major in BME at schools comparable to MIT when combined with an engineering major.

Master of Engineering in BME

The Master of Engineering in Biomedical Engineering (MEBE) degree is offered jointly by MIT's Division of Biological Engineering (BE) and Harvard-MIT Division of Health Sciences and Technology (HST) as a fifth-year program to MIT undergraduates.

This program educates individuals prepared for leadership positions in the medical products, pharmaceutical, or biotech industries. A secondary objective is to provide students who may be considering either a medical degree or a doctorate in biological engineering or medical engineering the opportunity to learn more about these fields.

The MEBE Program comprises coursework and a thesis. There are two tracks in the MEBE program: bioengineering (BE) track and medical engineering (ME) track.

Bioengineering (BE) Track

The bioengineering (BE) track is primarily the responsibility of the BE faculty, and it is based on the core underlying science of molecular cell biology. A common theme throughout the bioengineering core curriculum, which derives from the core curriculum of the bioengineering PhD program, is the integration of individual components of a biological system to describe both the spatial and temporal organization of the system as a whole, using rigorous engineering analysis and design principles. The scale of this integration maybe as small as individual molecules or as large as organ systems or whole organisms.

Students interested in a career at the interface of biology and engineering, in the biotech, pharmaceutical, or medical products fields are encouraged to consider this track.

Medical Engineering (ME) Track

The ME track is primarily the responsibility of the HST faculty, and it incorporates some educational resources of Harvard Medical School. It is designed to provide engineering students with an introduction to human pathophysiology and the application of engineering to medicine. The core subjects are selected life science courses that are part of the first-year HST medical curriculum.

Human pathology examines the structure of normal cells and tissues, and their response to injury and disease. The pathophysiology subjects provide students with an in-depth understanding of the structure and of at least two organ systems in health and disease, including both basic molecular/cellular/tissue mechanisms and clinical manifestations.

The ME track is particularly appropriate for students who desire to work on biomedical engineering problems closely associated with medical science.

Student Research Spotlight:

Melanie Cornejo, junior in Course 7, Biology, started working in Professor Luk Van Parijs' lab this past summer to pursue her interest in immunology and cancer research. With guidance from mentor Dr. Fei Hua, Cornejo's project focuses on elucidating the controversial relationship between caspase-8 and caspase-10 in death-receptor-mediated apoptosis. Currently spending about 12 hours a week on the project, Cornejo plans to continue it as Project Lab next semester, hoping to arrive at some interesting results by then.

"My interest in immunology arose a long time ago, and, in April of 2003, I decided that was time to do something more than just reading about it. I thought the best way to get involved was by sending Professor Van Parijs an email to find out if I could possibly join his lab that coming summer. He replied immediately and told me to come into the lab to talk to him and one of his Postdocs. I loved the description of the project they were offering me to join, so that I did not hesitate in accepting. This is how my work on the Fas- signaling pathway started."

Melanie Cornejo,
Course 7, Class of 2005

Elusive Role of Caspase-10 in Fas-mediated Apoptosis

By Melanie Cornejo

Introduction

Activation of the death receptor, Fas, by its ligand, FasL, induces programmed cell death or apoptosis. Fas-induced apoptosis plays an important role in maintaining homeostasis in the immune system, and its deregulation can lead to autoimmune disease and tumor progression by providing a survival advantage to potentially harmful or malignant cells. A better understanding of Fas-mediated apoptotic effects at the molecular level will provide deeper insights into diseases of the immune system.

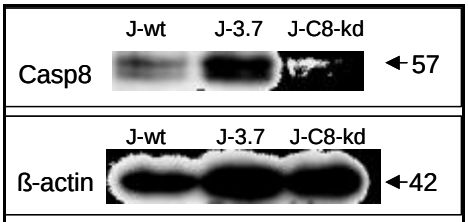


Figure 1. Western Blot of Knockdown Cell Line. Cornejo's preliminary findings demonstrated the lack of caspase 8 in the knockdown cell line (J-C8-kd) in comparison to the positive controls (J-wt and J-3.7). The bottom image is a normalization with β-actin.

Engagement of Fas by FasL triggers activation of a series of cysteine proteases, called caspases. Upon binding of FasL, Fas recruits initiator caspases, caspase-8 and caspase-10, and forms a death inducing signaling complex (DISC). Activated initiator caspases then trigger effector caspases either through direct cleavage or through a mitochondrial pathway, leading to the cleavage of many critical proteins and thus initiating cellular changes characteristic of apoptosis.

Results

Caspase-10 is a homologue of caspase-8 that is not present in mice, but appears to be important in human. It is yet unknown, whether this caspase is redundant to caspase-8 or if it fulfills another function within immune cells. The goal of my project is to decipher the specific role of caspase-10 in this pathway. The first step was to generate caspase-8 knockdown cell lines, using lentivirus-based RNA interference (RNAi) techniques. RNA-interference is a novel method for inhibiting gene transcription by targeting mRNAs for degradation using small interfering RNAs. This first attempt at this worked quite well (Figure 1 and Figure 2).

Future Work

The sensitivity of caspase-8, caspase-10, and caspase-8 and caspase-10 double knockdown cells to Fas-induced apoptosis will be established to determine whether both caspases are required to induce cell death. Coimmunoprecipitation (co-IP) will be used to pull down the whole DISC from wild type and knockdown cells to determine whether changes are observed in the composition of this structure.

An understanding of the role of caspase 10 in the Fas-signaling pathway is likely to aid the design of new therapeutic strategies to combat cancer and autoimmune disease.

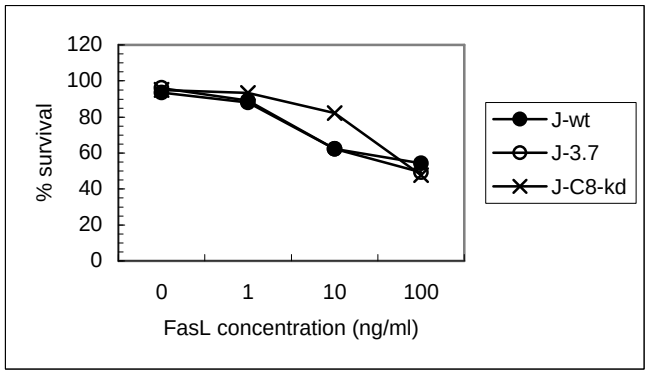


Figure 2. Apoptosis Assay Results. Cornejo's preliminary findings suggested the increased survival of the knockdown cell line (J-C8-kd) in comparison to the positive controls (J-wt and J-3.7) for the range of 1 to 10 ng/ml FasL concentration.

Johnson & Johnson

BMES - Johnson & Johnson Excellence in Biomedical Engineering Research Prize 2004

The MIT student chapter of the Biomedical Engineering Society (BMES) is devoted to serving the MIT community by utilizing bioengineering resources on campus and around the world and to encouraging student participation in the field. Johnson and Johnson is a world leader in healthcare and pharmaceutical products, and has for over 50 years relied upon the ingenuity and creativity of interdisciplinary biomedical engineers in creating innovations that serve to better human health. Our Excellence in Biomedical Engineering Research Prize was established because of a mutual vision between academia and industry that the true value of an interdisciplinary bioengineering education is realized while in the process of making novel scientific discovery. Our goal is to reward student accomplishment in this discovery process, and therefore promote innovation in this rapidly growing field at the world's premiere engineering institution.

Thanks to the collaborative support of the Division of Biological Engineering at MIT, and generous funding from Johnson and Johnson, **FIVE** of these prizes will be granted each year to MIT bioengineering students for outstanding research conducted at the undergraduate and Masters' (M. Eng./S.M.) degree levels.

Each winner will receive a cash prize of $900 as well as a chance to present his/her research at an MIT BMES general body meeting in the spring.

APPLICATION REQUIREMENTS

- Registered MIT undergraduate and Masters' students are welcome to apply. **Deadline: Tuesday February 17, 2004.**
- Research must be broadly related to Biomedical Engineering
- Applicants must complete an abstract submission form and a faculty nomination for the project.

For further information and an application, please visit:

http://web.mit.edu/bmes

Program Coordinators:
Lili Peng (lilipeng@mit.edu)
Vice President, Special Projects
Alexis DeSieno (alexisd@mit.edu)
President

Examples of BME-related Fields:
Biomechanics
Genetic & Cellular Engineering
Neuroengineering
Communication Science
Biomedical Imaging
BioMEMS
Therapeutics Development & Delivery
Molecular & Biochemical Engineering
Biomaterials
Physiological Mathematical Modeling
Bioelectronics & Instrumentation
Space Bioengineering
& Human Factor Design
Biomedical Informatics
Computational Biology
Radiation/Radiological Therapeutics
Tissue Engineering

RESEARCH PUBLICATION OPPORTUNITY
Student Research Spotlight

Why? Share your research! Strike a conversation, spark some interests . . .
It doesn't have to be ground-breaking, earth-shattering discoveries - just something cool you would like to share - simply because research is an ongoing dialogue, a work in progress fueled by interaction with fellow seekers of truth . . .

How? Consider publishing through the BioTECH, MIT's Biomedical Engineering Society (BMES) Newsletter. This could be a great opportunity to get feedback from faculty and peers with similar interests and pursuits, plus getting a head start on applying for the Johnson & Johnson Excellence in Biomedical Engineering (BME) Research Prize!

Guidelines for Submission:
1. Undergraduate research in a BME-related field.
2. A concise and informative description of research in approximately 250 words.
3. Include a brief blurb on the context of research (lab affiliation, mentor, how you got involved, degree and length of involvement, etc).
4. Jargon-free, reader-friendly language accessible to the general MIT community.
5. Approval from mentor if research is UROP-based, or clearance from employer if research is industry-based.

When? Contact us over IAP for publication in the next issue of the BioTECH.
Questions? Email TheBioTECH@mit.edu. We hope to hear from you soon!

BME News around the World: DNA Based Computer Anticipated

By Meiling Gao and Judy Yeh, *EDIOTORS*

DNA is well known as a 'blueprint' because these tiny strands hold the information that will run the processes in organisms. As scientists are unraveling the secrets of the messages encoded in DNA to make advances in science and medicine, other scientists are working on another use for DNA: computer chips.

Processors that are available on the market today are made from silicon, but soon these chips will reach their maximum speed and information capacity. Already, chip manufacturers are looking for a new material to build faster processors, and they think they've found it in DNA.

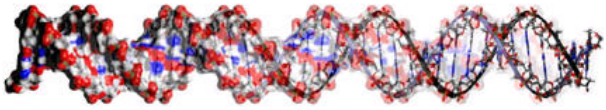
DNA's four nucleic acids – A, T, C, and G – are analogous to the zeroes and ones in the binary code, and its capabilities of encoding information are phenomenal. The power of DNA was further discovered when it was proven that DNA could solve complex problems such as the Hamilton Path Problem, and logic gates were subsequently made from DNA.

There are also advantages to using DNA instead of silicon in making computer chips. The supply of DNA will never become an issue as long as there are organisms, which makes DNA a cheap resource. In addition, DNA chips will not contain all the chemicals that are necessary to make silicon chips. Most importantly, DNA computers will be smaller and capable of holding more information.

However, it is not expected that any DNA computers will be on the market anytime soon. In its infancy, the DNA computer will most likely be used by the government to crack codes and solve complex problems rather than for personal use.

Directed Hamilton Path Problem

In 1994, Leonard Adleman solved the following problem using DNA. The problem was to find the shortest path between a number of points that goes through each point only once. Strands of DNA represent the number of points, and combinations of A, T, C, and G represent the paths connecting the points.



Source of image: http://alumweb.mit.edu/opendoor/200311/

These DNA strands were mixed together, and they would stick together at the ends with a chain of these strands representing a possible answer to the problem. All the possible combinations would be present in the test tube. Adleman was able to eliminate the wrong molecules or "answers" through chemical reactions, which left behind only the correct method of connecting all points.

DNA Computers and MIT

Five years after Alderman's seminal paper, the Fifth International Meeting on DNA Based Computers was held at MIT on June 14 and 15, 1999. One of the principal organizers of the Meeting was MIT EECS Professor David Gifford, who heads the MIT Programming Systems Research Group.

Along with Gifford, other key MIT players in the field of DNA computers include Dr. Alexander Hartmink and Dr. Julia Chador, then a graduate student under Gifford and now a postdoctoral associate at the MIT Lab for Computer Science.

Publications by Gifford et al. include "On the Path to Computation with DNA," a Science paper in 1994, and "Automated Constraint-Based Nucleotide Sequence Selection for DNA Computation," a presentation at the Fourth Annual Workshop on DNA-Based Computers in 1998.

More recently, MIT contribution in the field includes "Engineered Communications for Microbial Robotics," presented by Dr. Ron Weiss and Dr. Tom Knight, at the Sixth International Meeting on DNA Based Computers in 2000.

INTERNSHIP RESOURCES

Intel Corporation, Biotechnology Research Group
Contact Information:
Intel Corp., Mailstop SC4-311
Attn.: Mark Retzer
2625 Walsh Avenue
Santa Clara, CA 95051
E-mail: mark.c.retzer@intel.com
On-line resume submission site:
http://www.intel.com/jobs/students/

The following links were compiled from the National BMES website: http://www.bmes.org/internships.asp

Abbott Labs
http://abbott.com/career/campus_internship.html
Electronic resumes are accepted until February 28 2004.

The American Physiological Society, Undergraduate Summer Research Fellowship
http://www.the-aps.org/education/ugsrf/index.html

Johnson & Johnson, the Engineering Leadership Development Program (ELDP)
http://www.jnj.com/careers/eldp.html

National Institute of Health (NIH) Summer Internship Program in Biomedical Research
http://www.training.nih.gov/student/internship/internship.asp

Biogen
http://www.biogen.com/site/content/career/summer_internships.asp

Genentech
http://www.genentech.com/gene/careers/college/internships/index.jsp

Genzyme
http://www.genzyme.com/corp/careers/intern_positions.asp

Guidant
http://www.guidant.com/webapp/emarketing/careers/career.jsp?lev1=gdtoncampus&lev2=internship

General Electric
http://savelives.gecareers.com/campus.html

Medtronic
http://www.medtronic.com/employment/summerassoc.html

Wyeth
http://www.wyeth.com/careers/wpr_ur_undergrad.asp