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The BioTECH

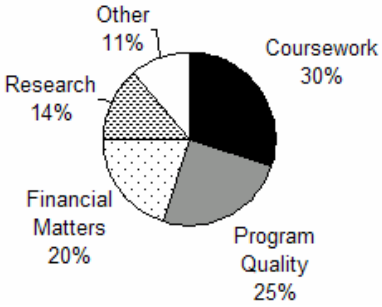
NEWSLETTER OF THE BIOMEDICAL ENGINEERING SOCIETY AND THE BIOLOGICAL ENGINEERING COMMUNITY

Undergrads and Grads in BE Survey

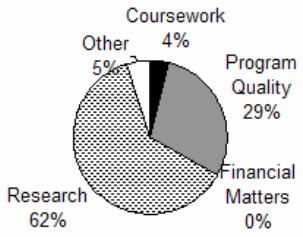
By *Brian Chase* '06, *MANAGING EDITOR*

The MIT Biological Engineering (BE) Student Board conducted a survey last spring of undergraduates and graduates involved in the BE program, asking them questions about the most attractive aspects of BE, what their academic plans are, and what BE could do to help its students. The results describe the types of undergraduates who are interested in the new program, but also bring to light some things that the BE program could do to attract more students in the future.

Undergraduates' Ranking



Graduates' Ranking



Of the 107 undergraduates surveyed, 30% ranked coursework as the most important factor in selecting a graduate program; 25%, program quality; 20%, financial matters; 14%, research. Of the 45 graduate students surveyed, 62% ranked research as the most important factor in their decision to enroll in the MIT BE PhD program; 29%, program quality; 4%, coursework.

Undergraduate Survey Results

The survey of undergraduates focused on what the plans of undergraduates involved in BE were, and how informed they were of their options for graduate education. The only major trend was that 80 of the 107 respondents were enrolled in the BME minor. This suggests that the minor is still the most popular way for students to get involved in BE. The undergrads were significantly more diverse on issues such as major and future plans. The respondents were from three majors principally: Biology, EECS, and Chemical Engineering with Mechanical Engineering running somewhat behind them.

When questioned about future plans, 30 respondents were unsure or undecided while 23 respondents planned to get a PhD or an MD. Part of the large numbers of undecided students can be explained by the fact that only 54 of those surveyed were juniors or seniors, so many of those undecided might have been freshman or sophomores. Still, it might be beneficial for the BE department to do more to educate the undergraduate BE

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BME @ Madison

A Bio" + "Engineering" Landscape @ MIT" feature was printed in the September 2004 issue of the BioTECH, and, in response to this coverage, several BMES chapters across the nation have responded with portrayals of the bioengineering landscape at their respective institutions.

Here is the first of a mini-series on "Bio" + "Engineering" Landscape @ Other Schools: "Biology and Engineering at the University of Wisconsin - Madison: a Student's Landscape."

By *Andrew L. Wentland,* *STUDENT AT UW-MADISON*

UW-Madison's major in biomedical engineering (BME) is one of the most sought after undergraduate degrees, not only in the college of engineering, but among all sciences. In freshman orientation, students are advised that only forty-five students are admitted into the program each year. The students not deterred by the warning still result in 250% of applications per student admitted. Why are so many students attracted to UW-Madison's degree in biomedical engineering?

Through a generous grant from the Whitaker Foundation, UW-Madison established an undergraduate BME program in 1999. The founding faculty members met with

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MIT (Biological Engineering)-Biomedical Engineering Society Publication

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The *BioTECH* is a publication by the MIT (Biological Engineering)-Biomedical Engineering Society (BE-BMES) as a vehicle to inform, involve, and mobilize our membership regarding the complex and evolving bioengineering landscape at MIT and nationwide. Founded in Spring 2003, the *BioTECH* has grown from a campus publication to one with wider constituencies, a bridge for inter-chapter relations and a catalyst to spark discussions on the national scene — the BMES Bulletin, for example, printed our *Letter to the Editor* in a full page coverage (p.3) of its summer 2004 issue <http://www.bmes.org/pdf/vol28_2.pdf>.

Letter to The Editors

Hi BMES Exec Members,

Thanks so much for your time [in hosting my visit to the MIT BE Department]. Your advice and answers to my questions were very helpful. I have learned a lot about MIT's engineering program and the new BE department, and now want to attend even more! I got to know more about the various majors and minors and the options available in the ChemE and BE areas - especially the differences between BioE, BE, and BME!

Christina [Feng, VP of Campus Relations] was very helpful in coordinating the meetings and working around everyone's schedules. Speaking with Prof. [Natalie] Kuldell and getting to see her lab was amazing, too; she was very helpful in explaining the new BE major and got me very interested in her work and the department. I was really excited to be talking to a MIT Professor!

Thanks again,
Ankita Mishra
Forest Ridge School of the Sacred Heart
Bellevue, WA

(BE)-BMES Co-Presidents George Eng and Julie Tse manned the booth at the Activities Midway on September 2, 2005 during Orientation Week. Over 150 new students signed up for the (BE)-BMES email list at the Midway.

Interview with Biotech Guru

Noubar Afeyan Comments on MIT's New Major and the Evolving Bioengineering Field

Dr. Noubar Afeyan is a managing partner and the CEO of Flagship Ventures, "a leader in creating, funding, and developing new ventures in both life science and information technology sectors." He is also a Senior Lecturer at MIT's Sloan School of Management and earned a PhD in Biochemical Engineering at MIT in 1987.

Outside of the office, Dr. Afeyan loves spending time with his family, playing basketball, and working on his non-profit endeavors, notably the Armenia 2020 organization that focuses on the economic development of Armenia, his native land.

By *Ali Alhassani '08*, *ASSISTANT EDITOR*

While in a Flagship conference room overlooking the Charles River and Boston's skyline, this prolific entrepreneur recalled to BioTECH representative Ali Alhassani his experience serving as a member on the Biological Engineering Division's Visiting Committee and what he foresees for the budding field of Bioengineering.

BioTECH: How does the industry demand respond to and/or drive the academic development of biological engineering?

Afeyan: When it comes to engineering a microbe, a crop, or a human protein replacement, initially, biologists did this. But in the next generation, you often found that engineers stepped in and did it in much more of a thoughtful, design-oriented, goal-oriented way. I think the industrial demand for people who have biological engineering familiarity is growing tremendously with biotechnology, with medicine, everywhere.

> "[Biological Engineering] to me is more at the edge of knowledge, at the edge of capability, and innovation usually finds a way to occur at the edges."
>
> ***Dr. Noubar Afeyan***

BioTECH: Since the fusion of biology and engineering is such an emerging field of study, do you think those who major in Biological Engineering or minor in Biomedical Engineering will be hotly sought after in the job market?

Afeyan: Sure. There are always frontiers and there are places that are not quite at the edge, where people have been before and are more inland if you will. This [BE] to me is more at the edge of knowledge, at the edge of capability, and innovation usually finds a way to occur at the edges. And I think BE is going to be one of the key edges where companies are going to be formed, and major companies will spend more money.

I have no doubt that many companies will flourish at the intersection of biology and engineering. These companies will be a major employer of biological engineers. I expect that some of these startups will in fact be created by biological engineers.

BioTECH: For those students who have aspirations to start biotech companies, how important is it to pursue a business/management education alongside life sciences and engineering?

Afeyan: I think that familiarity with the idea of what a company does is very important. A company is like a body: it has many different components that have to flow together. So if you take the body apart and study the kidney, the brain, and the heart, it really doesn't tell you how the body works; it tells you how the organs work. Similarly in a company, it's really not important to just understand finance or manufacturing or R&D, you really need to know how these things come together.

Now do you have to do a separate major? Can you do it through a minor? Can you do it through a handful of courses or do you go out and work for a while then get an MBA? I think all those things are case-dependent. But certainly I think if you have exposure to those subjects, you're better off.

BioTECH: Where do you see bioengineering five years from now, both scientifically and commercially?

Afeyan: I think there's going to be two forms of bioengineering: one is "Bio-something" engineering — Biomechanical, Biochemical, Bioelectrical, Biomaterials, etc., and then there's going to be Biological Engineering (BE). In BE, I think people are going to require the participants to be fluent in biology and engineering equally so that they will be essentially bilingual.

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Afeyan Interview

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There's going to be a whole set of problems that we don't at all imagine today, the solutions to which will be very valuable. The sign of a burgeoning new field is that no one can tell you what problems are going to be important five-to-ten years from now.

BioTECH: How popular do you see the new BE major becoming, compared to the more traditional majors (EE, ChemE, MechE, etc.)?

Afeyan: I think its going to be interesting to see. Certainly there will be plenty of students who will want to take those engineering disciplines; they are far more established. I think BE over the years will start small but will build its own definition of itself and its own view of the world. Its view will be centered on biology and every thing else will be in service of biology.

I think it will grow over time. People will look ten or twenty years from now, and they'll say, "That got started in 2005." But to me, the first five-to-ten years will be a bit of trial and error. It will be exciting to see where the graduates go; I think a lot of them will probably end up doing a graduate degree, but not all. There's going to be a bunch who are going to find themselves prepared for industry. This is going to be one of those tracks that people see if it fits their imagination, their aspiration. Today I think it will be interesting to see how it emerges and how it plays out.

Dr. Aaron Flores '91, '92, '96 described Cordis' invention of a glowing stent as part of their presentation at the first BMES General Body Meeting on September 21, 2005 in 56-614.

Diversity in BMES

Currently enrolled students who voted in BMES elections in the past two years, broken down by major:

Major	# Students	Percent of Total
Biology	32	30%
ChemE	23	21%
MechE	14	13%
EECS	12	11%
MSE	9	8%

There were 107 students total and 13 majors represented.

COMPANY SPOTLIGHTS

Students have found a variety of ways to experience BE/BME firsthand in industry at biotech/life sciences-related companies in the summer. In this section, the following students share their experiences:

Becca Luger-Guillaume '05, EECS - **MEDTRONIC, INC**.
Muyinatu Lediju '06, Mechanical Engineering - **MEDTRONIC, INC**.
Meiling Gao '06, Chemical Engineering - **CONVERGENT**
Heather Pressler '07, Biology - **LIMR**
Uche Enuha '05, EECS - **GUIDANT**
Mike Gebauer '06, EECS - **AGAMATRIX**
Jia Xing '06, Chemical Engineering - **PFIZER**

Alleviating Pain, Restoring Health, Extending Life

Medtronic, Inc., Minneapolis, MN

By *Becca Luger-Guillaume '05* and *Muyinatu Lediju '06*

The thought of entering the "real world" is frightening, for many reasons. However, when we first walked into Medtronic last summer, we were met with nothing but enthusiasm, intelligence, and creativity.

Medtronic leads the world in medical technology, by providing products such as pacemakers, insulin pumps, and neurostimulators. Even though its almost 30,000 employees around the world have different cultures, academic backgrounds, and languages, they all have the same three goals in their everyday work: to alleviate pain, restore health, and extend life.

We cannot tell you how many times we heard people around us mention the mission statement in a typical work-related conversation. According to our observations, employees are undoubtedly driven by the mission statement, and they are very passionate about upholding those three values. Medtronic is truly a company with a vision that molds its culture.

Becca and Muyinatu share their individual experiences on page 8.

No More Knots: Testing a Design for Nitinol Sutures

Convergent Care, Canton, OH

By *Meiling Gao '06*

Working for a company like Convergent Care is one of those eye-opening experiences that comes with its own unique stories. A medical devices company started by the chief cardiothoracic surgeon at Aultman Hospital in Canton, Ohio, Convergent Care was in its early stages of development. The six interns worked in a makeshift physical therapy room that was converted overnight into what would be our office and testing area.

The main project of the summer evolved around developing and testing a design for a new type of suture made from the memory metal, nitinol. Memory metals, after undergoing a shaping process, can "remember" its shape even if it is forced into another form, and it will exert force in an attempt to revert back to its original shape.

> "One important lesson I learned about working in industry is that almost anything can be learned on the job."

Currently, surgeons must tie approximately 7 knots for each suture, and in surgeries such as valve replacements, over twenty sutures may be used to secure the prosthesis, which could substantially lengthen the procedure. I saw a few open-heart surgeries to experience just how tedious a process it is. Using nitinol, we tested a design that would allow surgeons to sew up a patient without the hassle of tying knots and conducted tests on fresh cow and pig hearts (apparently, slaughterhouses are fairly common in Ohio).

As a chemical engineer working with two other mechanical engineers, I was clearly the odd one out. One important lesson I learned about working in industry is that almost anything can be learned on the job. I might not have taken the same classes as the other two interns, but I had a similar engineering

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Company Spotlight: Exploring Opportunities in BE/BME-related fields

Gene Therapy for Ovarian Cancer Cells

Lankenau Institute for Medical Research, Wynnewood, PA

By *Heather Pressler '07*

Past the conference rooms, white lab coats, and instruments, an innocuous clear liquid waits in an Eppendorf tube on a lab bench. Less than a milliliter of this liquid holds a treatment, a future, an entire summer of work. At the Lankenau Institute of Medical Research (LIMR) I had the opportunity to create a new gene therapy vector for ovarian cancer.

LIMR began as a research department in Lankenau Hospital and became a separate non-profit organization in 1925. Since 1925, LIMR has expanded to include conference space, sixteen labs, and support staff. LIMR continues to encourage an educational and collaborative relationship with doctors at Lankenau Hospital. The unique patient and facility resources available to LIMR are mainly due to its close relationship with Lankenau Hospital.

At LIMR, Dr. Janet Sawicki, gave me the opportunity to work on gene therapy in her lab. As I learned, gene therapy has experienced many unfortunate set backs. However, it is still one area of scientific research that exemplifies the idea of bioengineering. Making a gene therapy vector is equivalent to going to the hardware store and collecting four tires, a frame, a steering wheel, and an engine that are individually useless, but once pieced together make a car.

> "Making a gene therapy vector is equivalent to going to the hardware store and collecting four tires, a frame, a steering wheel, and an engine that are individually useless, but once pieced together make a car."

To build the ovarian gene therapy vector, I pieced together a diphtheria toxin gene, a promoter from ovarian cancer, and a yeast recombination enzyme gene. Together these genes worked to successfully kill ovarian cancer cells, while sparing non-ovarian cancer cells.

LIMR's summer internship program not only gave me lab skills, but I was also introduced to the possibility of research and educational collaboration between physicians and researchers. LIMR gave me more than I could have ever asked for this summer: an opportunity to help 16,000 women battle ovarian cancer.

Optimizing Procedures for the Pacemaker and Defibrillator Industry

Guidant, St Paul, MN

By *Uche Enuha '05*

Working with Guidant is always a blast. This was actually my second internship with the company, and I was very pleased with my experience the second time around.

Guidant is in the pacemaker and defibrillator industry, and their main goal is to deliver highly efficient technologies to improve the quality of people's lives. They continue to collaborate with leading medical institutes to develop more appropriate methods to solve heart related diseases and are very successful in doing so.

My main job function was to research and evaluate tools for the test engineering department in order to optimize their testing procedures. Most of the work was software-related, but I was able to get a feel for the actual devices that they test, even though I did not work directly with them. I was given all the training I needed for the job once I arrived on Guidant's campus, but I will say that having already done a UROP, the research aspect of my job was familiar territory. Also, having taken 6.033 (Computer Systems Engineering) and 6.170 (Laboratory in Software Engineering) enabled me to assimilate the testing procedures a lot faster, as I was already familiar with certain terminologies.

> "The work [Guidant employers] do is also something that keeps you motivated to wake up every morning and put your best foot forward. They save lives."

Apart from the work I did at Guidant, there were so many other great sides of Guidant that kept me having fun all through the summer. Guidant provides a lot of fitness information to keep its employers healthy. They also have fitness classes onsite and a clinic that's very accessible. Guidant also sponsors a lot of events for the community which includes food drives and races to raise awareness about heart diseases.

The main reason I continue to be an advocate for Guidant is because they truly value their people. The atmosphere at Guidant is one that I have not found in other companies, and the people I have worked with

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Company Spotlight: Exploring Opportunities in BE/BME-related fields

Biosensors, Signal Processing, and the World of Diabetes

AgaMatrix, Inc., Cambridge, MA

By *Michael Gebauer '06*

According to the American Diabetes Association, 18.2 million people in the U.S. have diabetes. A significant portion of these people must test their blood glucose levels several times per day. Testing requires a person to draw blood and apply it to a meter, which returns a concentration of blood glucose. Regrettably, this process can be tedious, painful, and inconvenient. That's where AgaMatrix, Inc. comes into the scene.

AgaMatrix combines digital signal processing with innovative biosensors. The digital signal processing is the key. It makes it possible to test more accurately with a smaller sample of blood. Consequently, tests are less painful and more trustworthy. The AgaMatrix meter will be on the market in the near future.

An introductory college chemistry background is enough to understand the basic concepts. Beyond that, many academic backgrounds are relevant to AgaMatrix: chemistry and biology are needed to develop test strips and reagents; mechanical engineering is needed to develop the meter; electrical engineering and computer science are needed to implement the digital signal processing technology.

> "All the skills that an employee has are put to use – employees aren't locked into a repetitious job day after day."

As a research associate, I studied the medical device market to better understand the world of diabetes. I came in contact with the company through Devon Biondi from the UPOP program at MIT. She spoke very highly of AgaMatrix. After working there, I too left with a very positive impression.

The working environment is one of the best parts. There are opportunities to get involved with many aspects of the company from lab work to design work to marketing work. All the skills that an employee has are put to use – employees aren't locked into a repetitious job day after day. The mission is to get things accomplished.

Over the summer I felt myself genuinely getting caught up in the successes of the company. I wanted to make things happen — not just put in 8 hours per day and go home. Without question, I would recommend AgaMatrix as a strong, growing company in the Boston area that offers great internship opportunities.

Guidant, St Paul, MN

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are brilliant at what they do. The work they do is also something that keeps you motivated to wake up every morning and put your best foot forward. They save lives. Not many companies can say that. If the kind of people you work with and the impact of your work are important to you, then I would highly recommend working for Guidant.

Convergent Care, Canton, OH

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background and it's amazing how fast people can learn from each other.

Since it is a startup, what kind of experience you get from this type of internship solely depends on you. Taking initiative goes a long way in a small company, and the work that you do has a huge impact. By the end of the internship, I had drafted up a patent and a paper, which I'm currently submitting to a cardiothoracic conference, and I'm also researching ways to develop a better prosthetic mitral valve. I would definitely recommend this internship to people who are self-motivated and love a hands-on experience.

Company Spotlight: Exploring Opportunities in BE/BME-related fields

Alleviating Pain, Restoring Health, Extending Life (cont'd.)

Medtronic, Inc., Minneapolis, MN

By *Becca Luger-Guillaume '05*

My assignment for the summer was to create a graphical application for viewing pacemaker simulations. This was part of an overall goal for my software group in the Cardiac Rhythm Management research area to speed up testing and productivity. The part of this project that had the most impact on me was its importance. I've had UROPs and other internships, but nothing I've done will ever have as much impact on a person's life as what I did at Medtronic.

> "Since I left, my group has been using my program to speed up the process of starting new pacemaker algorithm tests as well as the general productivity of the group..."

On my recent trip to Minneapolis when I stopped by to see my boss from the summer, he beamed as he brought up a window that he was currently using: *my* program. Since I left, my group has been using my program to speed up the process of starting new pacemaker algorithm tests as well as the general productivity of the group, making it possible for new patients to receive better pacemakers sooner.

Although my programming classes prepared me to learn the programming languages I needed for my project, they couldn't prepare me for the significance of what I did this summer and what Medtronic does in general. I wished I had paid more attention to dreaded 6.170's lessons on documentation techniques. Success of a medical technology company does not come with sloppy code or laziness.

The environment I was in encouraged me to come up with my own solutions to unknown problems, defend my opinions, and learn from others. You may say this is typical of most companies, but as a computer science major, I was intrigued by biotechnology…enough to now want to go to graduate school for it.

I had an eye-opening experience at Medtronic: I learned that I love biotechnology, I was pushed to my limits and succeeded, and I discovered a company that truly does focus on its customers and not on politics. Medtronic is a place for people with enthusiasm to help others, as well as for those who love to learn. If you don't want to be passionate about your work, don't go to Medtronic.

By *Muyinatu Lediju '06*

My experience at Medtronic was rather unusual in that I had the opportunity to work on a number of different projects. One of my projects was to help with the testing and analysis of leads. A lead is basically the insulated wire that connects to the pacemaker; it's inserted into the heart for communication between the pacemaker and the heart, and it also serves as the mode of stimulation for pacing the heart.

I composed a simple model of the lead and conducted a non-linear finite element analysis (FEA) on the lead in order to identify component bending stresses in the lead. Since these stresses are very small, they can not be readily identified by simple testing of the actual lead. This project helped me to gain an appreciation for the FEA modelers in the group. Their job requires a deep insight and understanding of Medtronic's products and their resulting uses and applications. For example, there are many situations in which the lead bends: it bends during assembly, it bends during insertion in the heart, and it also bends as the heart beats.

> "It's one thing to create devices for inanimate objects, but when the device is for living human beings, the repercussions are enormous."

After speaking to the employees in my area, I was able to identify another project that interested me. My supervisor was gracious enough to allow

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HOW WAS YOUR SUMMER EXPERIENCE?

Email **TheBioTECH@mit.edu** to find out how your article can appear in the next series of Company Spotlights.

Company Spotlight: Exploring Opportunities in BE/BME-related fields

Comparing Research in Industry to Research in Academia

Pfizer, Inc.

By *Jia Xing '06*

Pfizer Inc. is the largest pharmaceutical research and development company in the world, marketing products in 150 countries. It leads the industry in discovering, developing, manufacturing, and marketing prescription medicines for human and animal consumption. The company has three business sectors: health care, animal health, and consumer health care. With a wide range of research projects in 18 therapeutic areas, the company pioneers new developments in the pharmaceutical and biotechnology area.

Throughout high school and my freshman year, I've only been exposed to working in research labs in academia. I enjoyed the experiences and expected to do the same the summer of my sophomore year. Nevertheless, out of curiosity, I sent my resume to some pharmaceutical and biotech companies. After a number of interview requests, I decided to work for Pfizer at their main Research and Development campus in Groton, Connecticut. The experience proved vastly different from working in academia.

First of all, the facilities were better, and resources were more readily available. Even as an intern, I was given my own cubicle, half a room of lab space, and the opportunity to use specialized equipment. Also, most of the researchers weren't worried about funding.

Second, the environment puts more emphasis on good communication and interpersonal skills. I met with some upper-level managers during lunch, and they all stressed the importance of soft skills for every company employee. Scientists, engineers, and managers must all associate with each other on a daily basis. There is also great collaboration among the different departments.

Third, company research is conducted based on market value. Research and development efforts are expected to bring profit, so there is less personal freedom in choosing research topics than in academia, and people tend to multi-task.

Fourth, there is more career movement within industry. For example, most of the employees that I spoke to have transferred between several departments or have moved up the corporate ladder over the years.

Although I find my experiences in both academia and industry very stimulating, I am glad that I decided to explore beyond academia this summer. It was worthwhile to try industry, even if it was just for a different perspective from academia.

Alleviating Pain, Restoring Health, Extending Life (cont'd.)

Medtronic, Inc., Minneapolis, MN

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me to assist those employees with the ongoing project. This project entailed building lead stimulation prototypes. I enjoyed this project because of the freedom associated with assembling the leads.

This class of stimulation leads was a novel idea, and there were no set guidelines to follow. In fact, I was responsible for documenting my work in a laboratory notebook so that others who followed me would be able to replicate the prototypes that I built. In retrospect, the class 2.671 (Measurement and Instrumentation) was very helpful for this type of work. It teaches you how to conduct laboratory experiments, document procedures, and report findings.

In the medical industry, documentation is very important. It's one thing to create devices for inanimate objects, but when the device is for living human beings, the repercussions are enormous. In many cases, dealing with medical devices is a life-or-death situation; it's very important to document your work so that steps can be revisited, retraced, and repeated.

I enjoyed the time I spent at Medtronic. The internship helped to strengthen my desire to work in the medical industry. I certainly identify with Medtronic's mission statement and it's essential that every member of the company embraces the mission to alleviate pain, restore health, and extend life.

Undergraduate BE Survey Results (cont'd.)

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students about what their options are and why those options might be desirable for different people.

The main questions in the survey centered on those students who were choosing to enter graduate school and how informed they considered themselves about MIT's program as well as other programs around the country. Those students who were considering applying to graduate school were asked to rank what factors they considered important. No one category ranked extremely high in this survey. The course program and coursework were ranked the most important factors by undergraduates, followed closely by research, location, and tuition/cost.

When asked whether they felt informed abut graduate school, 73 of 107 undergraduates polled said they felt informed of MIT's graduate programs, but only 37 of those 107 felt informed about graduate programs other than MIT's. Of those that did feel informed, many mentioned seminars arranged by BE student groups or meetings with MIT professors. While this shows that the Biomedical Engineering Society (BMES) is informing some undergrads of the opportunities in grad schools outside of MIT, it may want to try to do more to reach out to students with questions, as well as to try to bring top notch schools to its presentations. Many of those students who were looking at other schools were looking at places that had not had a representative at MIT recently, including Johns Hopkins, Duke, and Stanford. The questions students wanted to pose to these representatives were not that surprising; they mainly focused on the work, the admissions requirements and trends, and the structure of their programs and research. Should BMES wish to present school reps with a list of questions to have answers to beforehand, these survey results would prove quite useful.

Undergraduate Student Survey for the BE Diversity Group

1. What year are you?
2. What is your course number?
3. Are you minoring in BE?
4. What are you doing after graduation? (Work, MS, PhD, MD, JD, Undecided, other)
5. If you have decided, what year were you when you made the decision?
6. If you are, or are thinking of, entering a PhD program, rank the following in the order of importance with respect to choosing a graduate program:
   _____ Financial Matters (Stipend, Expenses, etc.)
   _____ Potential Advisors / Research Opportunities
   _____ Program or School Reputation / Prestige / Ranking
   _____ Course Work / Overall Curriculum / Qualifying Exam Structure
   _____ Location / Atmosphere
   _____ Average time to earn desired degree
   _____ Diversity of student body and faculty
   _____ Other (please elaborate)
7. Do you feel that you have access to information about graduate programs?
8. Have you received information about graduate programs outside of those at MIT, and if so from where?
9. Are you aware of the requirements for applying to different graduate programs?
10. If someone from a different school's graduate program visited MIT, what information would you most like to get from them?

Graduate Survey Results

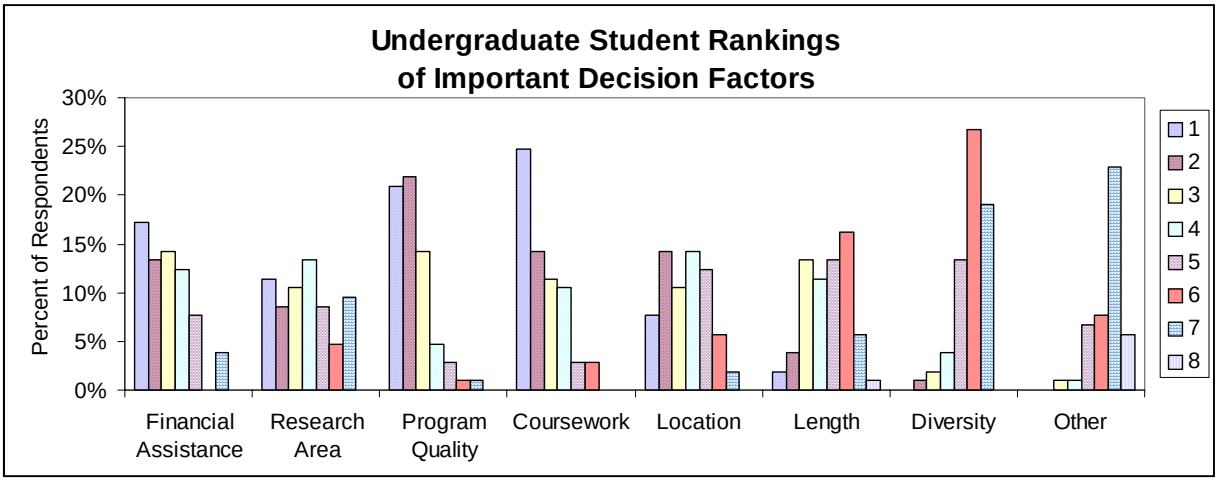
A total of 45 graduate students took a graduate survey that identified some strengths as well as some shortcomings of the BE program. Most of the students said they did not choose BE over a more traditional major; rather they pursued BE as their primary option.

When asked why they joined BE, the most common responses were the enthusiasm of the faculty and the excellence and uniqueness of the curriculum. The fact that MIT's BE program and research integrated biology and engineering was understandably a big selling point for many of the people surveyed.

When the students were asked to rank the factors they considered most in coming to MIT, the unique research was the most important reason.

The other important factors include the program, the coursework, and the location. All of this reflects well upon the MIT BE

(Continued on page 11)



A ranking of 1 denotes the most important decision factor while 8 denotes the least important: 25% of the respondents selected "Course Work / Overall Curriculum / Qualifying Exam Structure" as the #1 most important factor in choosing a graduate program; 21% selected "Program or School Reputation / Prestige / Ranking"; 17% selected "Financial Matters (Stipend, Expenses, etc)."

Graduate BE Survey Results (cont'd.)

(Continued from page 10)

Grad program's core classes, subjects, and research, as well as the faculty who run them.

Besides the coursework and research, the BE grads surveyed found several other things to praise. Many of the students commented on how intelligent, well-rounded, and considerate the people involved in BE were. Several liked the challenges that BE had to offer. Still more were impressed by the small class sizes and communities in the program, complemented by the high degree of collaboration noticed between labs and professors. And finally, the enthusiasm of the professors for their subject material was emphasized repeatedly throughout the survey.

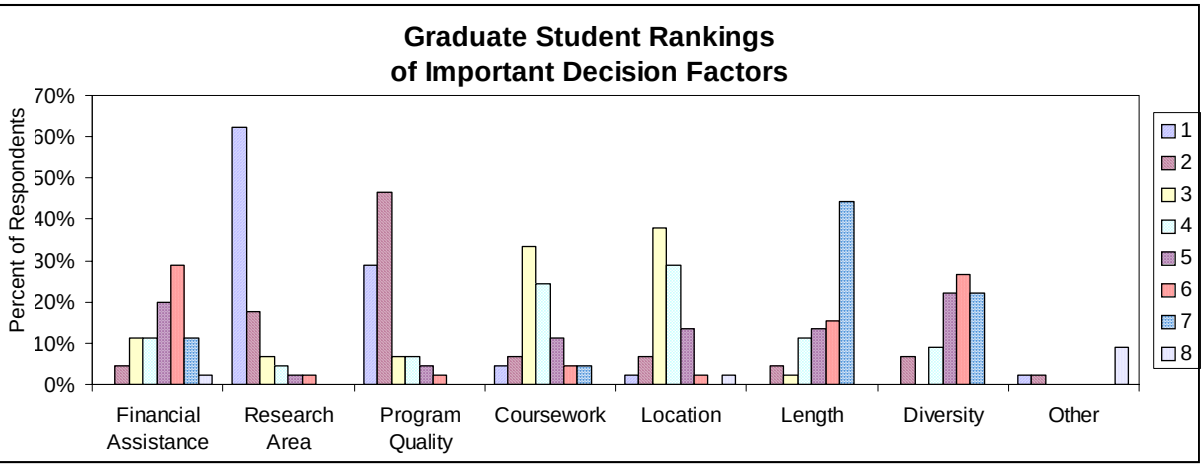
Besides all the praise heaped on MIT BE, there were a few things that students thought could be improved. Most of their complaints stemmed from the structure, or lack thereof, in the administration of the program. Several commented that they wished the requirements for the different tracks, especially Toxicology, were better defined, and that there was more structure involved in picking an advisor. At the same time, a number of other students wanted more freedom in the class work choices offered in the first year, including the opportunity to experience some lab work. Probably the most serious concerns voiced by a few students are that the Applied Biosciences track is not well defined and has grown too far from the Engineering track, and that the program as a whole is not as welcoming to students with a science background as it is to engineering students. It appears that the problems grad students have with the BE program are not rooted in the material, but in the administration-- something that hopefully will be easier to fix. Steps in the right direction are already being made: the Applied Biosciences track and the Bioengineering track now share more classes than they did when this survey was taken.

As a new and burgeoning field for both graduates and undergraduates alike, BE at MIT needs to be attuned very highly to the desires of its students. This new survey of BE graduates and undergraduates by the BE Student Board reveals several things: both programs are doing well, especially in regards to the coursework and knowledge involved in BE itself. However, more advertisement of the opportunities in graduate school for BE undergraduates and better administration of the Graduate major might help BE attain an even higher level of excellence here at MIT and enhance the experience for MIT BE students of all levels.

The BioTECH Staff would like to thank Nathan Tedford G, BE Student Board executive member, for providing the survey results and reviewing this article.

Graduate Student Survey for the BE Diversity Group

1. What year are you?
2. When deciding on a graduate program, were you deciding between BE and a more traditional engineering or pure science program? Why did you pick BE?
3. Why did you choose to pursue a PhD over an MS, an MD, another degree, or a job?
4. Were you aware or well informed in advance of what was required of you to apply to the graduate programs you were interested in?
5. What made you want to come here to MIT? Please rank the factors below in order of importance for your decision to enroll in the BE program (1 being most important).
   _____ Financial Matters (Stipend, Expenses, etc.)
   _____ Potential Advisors / Research Opportunities
   _____ Program or School Reputation / Prestige / Ranking
   _____ Course Work / Overall Curriculum / Qualifying Exam Structure
   _____ Location / Atmosphere
   _____ Average time to earn desired degree
   _____ Diversity of student body and faculty
   _____ Other (please elaborate)
6. What has been the most attractive aspect of the program to you since you've come here?
7. What do you like the least about the program?



A ranking of 1 denotes the most important decision factor while 8 denotes the least important: 62% of the respondents selected "Potential Advisors/Research Opportunities" as the #1 most important factor in their decision to enroll in the BE graduate program; 29% selected "Program or School Reputation / Prestige / Ranking"; 4% selected "Course Work/Overall Curriculum/Qualifying Exam Structure."

Biology and Engineering at the University of Wisconsin - Madison: A Student's Landscape

(Continued from page 1)

representatives from some of the biggest names in the medical industry, such as Medtronic and GE Medical Systems. These representatives told faculty members that, in their experience, graduates of biomedical engineering programs had solid understandings of biology and engineering principles, but rarely did those principles come together. Instead of hiring biomedical engineers, these companies hired mechanical and electrical engineers and trained them in biology—only what they needed to solve problems.

As a result, graduates of biomedical engineering programs typically went to medical school and graduate school. Rarely could a graduate establish a career in the medical industry.

When UW-Madison's faculty began to form the BME curriculum, they included all of the foundational classes that an engineer would take—statics, dynamics, circuits—but also all of the foundational classes of a biologist—biology, physiology, and organic chemistry. Upon completing these numerous core classes, students would need to take the core classes of biomedical engineering, namely biomechanics, bioinstrumentation, and biomaterials. Each student would be allowed to focus in a certain field in biomedical engineering, taking four additional classes in categories like biomechanics, medical imaging, and ergonomics. These courses still provided a fairly broad background. How could the faculty adequately prepare students for medical school, graduate school, or a career in industry?

The answer? Design. Through a mere 6% of the total number of credit hours in the undergraduate BME curriculum, every student would take six semesters of biomedical engineering design. Don't be misled by the paucity of this percentage. With five of the six classes being a single credit hour and the sixth being three credit hours of capstone design, sophomores, juniors, and seniors work directly with medical doctors, nurses, graduate students, Ph.D.'s, and engineers from the medical industry. These clients provide projects in every imaginable category of biomedical engineering, from combining biomechanics and gastroenterology to biomaterials and surgery. Inherently, these classes are much more valuable than the number of credits they provide, including the chance to work in teams, to experience real world problems, to interact with medical professionals, to practice presentation and writing skills, and to work with proposals and funding.

> Six semesters of design teach students how to learn and help them define where they want to go with their careers.

Biomedical engineering design lends itself to three years of rigorous training, with students challenged in advanced problems while learning how to design and becoming well qualified for careers in the medical industry. However, six semesters of design "was even better than envisioned, because students started learning how to learn and the projects started helping students define where they were going with their careers," said Professor Robert G. Radwin, chair and founder of the Department of Biomedical Engineering. Design became "a new way to learn." With these projects beginning in the undergraduate's sophomore year, design influenced students to take courses suggestive of the projects they worked on, and as a result, the projects helped define students' careers.

An estimated 75% of students entering BME are pre-med. Most of the remaining students tend towards graduate school. But with all the interaction the design courses provide, many of these students change their minds. Some enjoy design to such a level that they apply for industry upon graduation. A few of the pre-med students, having worked with medical doctors in numerous fields through the design courses, decide that graduate school is right for them; and vice versa for the students intending to enter graduate school. By the time they graduate, only 25% of students are bound for medical school.

These design classes are powerful learning tools, providing so much flexibility that students planning to attend medical school may work on projects in several different fields to understand the broad scope of medicine; students planning to attend graduate school may focus on projects that are research-oriented; and students intending to work in the medical industry may, for example, emphasize electrical engineering in their coursework and subsequently

(Continued on page 13)

Students sit in on a BE-BME info session on Registration Day, filling the entire 56-114 classroom. Representatives from several majors including BE and Computer Science were on hand to answer students' questions.

(Continued from page 12)

choose numerous projects involved in bioinstrumentation.

The design courses help students use their engineering knowledge to design something of clinical relevance. "If students are interested in learning how an engineering approach can be used to understand something more fundamental about cells and tissues, a new certificate program may be just the ticket," said Professor Naomi Chesler, professor of biomedical engineering and graduate of the HST Division of Harvard-MIT. Professor Chesler is helping to establish a Biology in Engineering certificate (UW-Madison's equivalent to a minor) that will expose engineering students to the ways in which engineering has and can contribute to problems in biology. The certificate is not just for students majoring in BME, but for any student in the college of engineering.

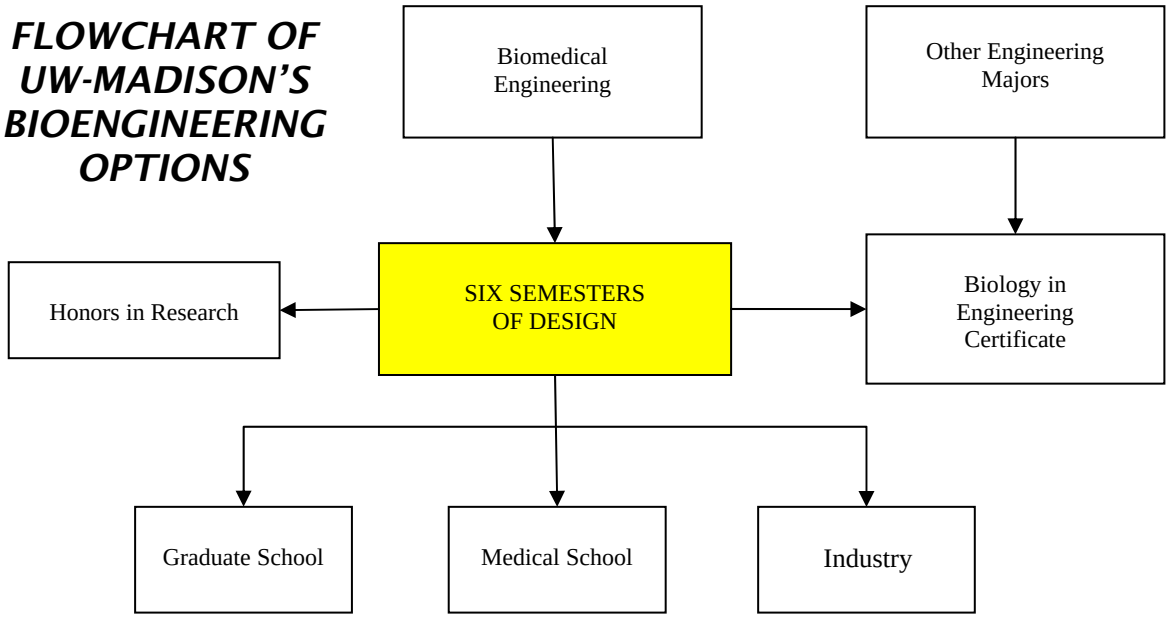
The certificate allows students to "learn more about biology and integrate that knowledge with their engineering training through a capstone seminar course," said Chesler. The seminar course covers a broad spectrum of topics—what could be considered the scope of biological engineering at UW-Madison. These topics include rheology of DNA, nanoscale biosensors, tissue engineering, mechanical properties of arteries, gene therapy and drug delivery, and imaging technologies for cancer detection, in effect sampling the many research programs on campus that are involved with using biological principles in biological applications.

One of the BME department's own biological engineers is William Murphy, whose work focuses on developing materials to instruct stem cells. Murphy said, "Many of the most intriguing problems in biology exist in medicine. In many cases, biological engineers will end up doing the same thing as biomedical engineers," in that as biological engineering becomes more advanced, basic research, such as Murphy's, will be directly applicable to clinical problems. Perhaps as tissue engineering advances, biologics and clinical applications will become the predominant foci of the field.

Biomedical engineering at UW-Madison encompasses all aspects of biology and engineering, whether that is engineering for direct medical application, or fundamental biological research, such as Murphy's. From a student's perspective, course work emphasizes the former—clinical relevance in mind. Nevertheless, the department of biomedical engineering offers a program named Honors in Research, which allows any undergraduate student in the department to work on biomedical/biological research for a minimum of three semesters. This research can be done with any professor in biomedical engineering or any professor associated with the department. Those professors cross-listed in the department range from radiology, oncology, rehabilitation medicine, physiology, and all of the departments in the college of engineering. Therefore, a student in BME not only works on clinical problems in the design courses, but can also work in biological research.

Biomedical engineering is the epicenter of biology and engineering at UW-Madison. UW-Madison focuses on direct medical applications, which are epitomized in biomedical engineering design, to help foster a career path for undergraduates. BME students are empowered to explore and determine their involvement in medicine, biology, and engineering, whether that is going to medical school, graduate school, or industry.

Andrew Wentland is a senior in biomedical engineering at the University of Wisconsin – Madison. He plans to pursue a MD/PhD program in the hopes of emphasizing MRI medical physics in his PhD work.



present:

The 2005-2006 EMBS-BE/BMES Distinguished Lecture Series

High-Throughput Mass Spectrometry: From Concept to Commercialization

Distinguished Speaker:

Dr. Can C. Özbal

Program Manager, RapidFire™ Lead Discovery
BioTrove Inc.

Mass spectrometry (MS) is a powerful analytical tool that has the ability to quantify selected analytes based on molecular weight. As such, MS has become a widely used tool in many phases of drug development, ranging from target discovery and validation through lead optimization and biomarker discovery. One limitation of the use of mass spectrometry is the incompatibility of the method with samples that contain non-volatile components, such as salts and buffers, due to ion suppression and precipitation in the MS ion source. Analysis of such samples requires an initial chromatography step that is typically the rate-limiting factor on MS throughput. BioTrove has developed the RapidFireTM MS interface that enables sustained throughputs of MS systems at 4 to 8 seconds per sample, enabling the use of mass spectrometry in primary screening for lead compound identification. The talk will focus on the technology and its commercialization.

After receiving an A.B. in chemistry with honors from Bowdoin College, Dr. Ozbal joined the laboratory of Steven Tannenbaum at M.I.T. where he earned his Ph.D. in Toxicology. Dr. Özbal left M.I.T. to join BioTrove as one of its first employees where he was responsible for much of the RapidFire technology development, including the ultra high throughput mass spectrometry interface. Currently he is the manager of the RapidFire business unit at BioTrove and is involved in both commercial and scientific operations.

Wednesday, October 12 2005 at 7PM (Refreshments at 6:30PM)

MIT Building 66, 25 Ames Street, Room 66-110

Timeline & Calendar of Events for Bioengineering Opportunities

October:

10/6 "Meet the Lab" (Prof. Kristala Jones Prather of MIT) *56-114 at 4:10PM*

10/12 "High Throughput Mass Spectrometry" (Dr. Can Ozbal of BioTrove) *66-110 at 6:30PM* **[EMBS-BMES Distinguished Lecture Series]**

10/13 "Challenges in the Biopharm Industry and the Role of the Center for Biomedical Innovation" (Dr. Frank Douglas) *56-114 at 4:10PM*

10/20 "Effect of Adhesion and Mechanical Signals on Eukaryotic Cell Differentiation: Lessons from Yeast and Human Embryonic Stem Cells" (Prof. Sean Palacek of U. of Wisconsin) *56-114 at 4:10PM*

10/27 Dr. Cecil Plickett of the Schering-Plough Research Institute *56-114 at 4:10PM* **[Wogan Lecture]**

10/28 "Special Bioethics Seminar" (Thomas Shannon of Worcester Polytechnic Inst.) *56-114 at 1:30PM* **[BE Industrial Seminar Series]**

November:

11/3 "Meet the Lab" (Schauer Group of MIT) *56-114 at 4:10PM*

11/10 "The Met Receptor Tyrosine Kinase: Tubes, Tumorigenesis and More" (Dr. Morag Park of McGill U.) *56-114 at 4:10PM*

11/17 "Engineering Synthetic Multicellular Systems" (Prof. Ron Weiss of Princeton U.) *56-114 at 4:10PM*

December:

12/1 "Hyaluronan-based Matrices in Inflammation" (Dr. Vince Hascall of Cleveland Clinic) *56-114 at 4:10PM*

12/2 Mark Trusheim (Massachusetts Biotechnology Council) *56-114 at 1:30PM* **[BE Industrial Seminar Series]**

Student Research Spotlight (cont'd.)

upregulated in limiting phosphate conditions.

It has been hypothesized that *pstS2* plays the central role in phosphate uptake for Mtb. These two experiments support this hypothesis. Further experiments are needed, and are currently in progress, to examine and understand the role *pstS2* plays in phosphate uptake and Mtb virulence.

These experiments can help us to understand the importance of phosphate uptake in similar pathogens. The Pst system could be a potential drug target for the treatment of TB.

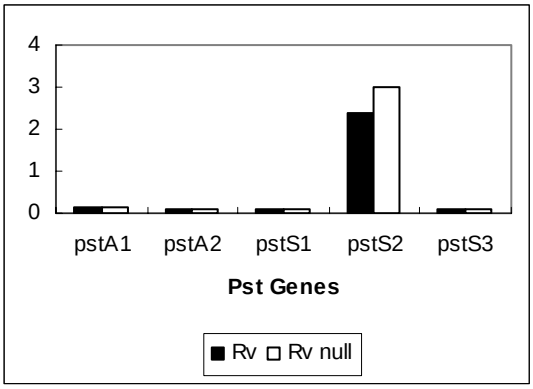


Fig. 2 Expression of 5 targeted pst genes in both phosphate and no-phosphate conditions using quantitative RT-PCR. It seems that the pstS2 gene has more expression in both conditions than the other 4 genes.

[1]Gateways to the Laboratory Program, Weill Cornell/Rockefeller/Sloan-Kettering, Tri-Institutional MD-PhD Program, New York, NY

[2]Massachusetts Institute of Technology, Cambridge, MA

[3]Lab of Infection Biology, McKinney Laboratory, The Rockefeller University, New York, NY

Student Research Spotlight

Exploring the Role of the Pst System in Pathogenesis of *Mycobacterium Tuberculosis*

Gateways to the Laboratory Program, Weill Cornell/Rockefeller/Sloan-Kettering, Tri-Institutional MD-PhD

Sophia Kamran is a current sophomore at MIT planning to be a biology or a BE major. She spent her summer in the Weill Cornell/Rockefeller/Sloan-Kettering Gateways to the Laboratory program researching the genes responsible for the counter-immune defense of tuberculosis.

By *Sophia Kamran'08*

Mycobacterium tuberculosis (Mtb), the etiological agent of tuberculosis, persists within the human host despite a vigorous host immune response. The bacterium uses specific counter-immune strategies to persist in host tissues, specifically macrophages.

Despite the fact that drug therapy against TB has been available since the early 1950's, full understanding of Mtb pathogenesis and worldwide control of TB still elude scientists and physicians today.

By studying Mtb, we can learn more about the environment and host defenses Mtb must overcome in order to survive within a host's macrophage. It is clear that Mtb has evolved specific counterimmune (cim) strategies to resist the immune system.

Using signature-tagged transposon mutagenesis (STM) as a screening method, several *M. tuberculosis* genes have been identified that are involved in counter immune responses. My summer research focused on one gene, *pstA1*, that came out of the screen.

PstA1 is part of a system known as the Pst system that is activated to take up phosphate in limiting phosphate conditions. Only few virulent microorganisms have this Pst system.

The Mtb genome has two *pstA* domains as well as two *pstC* membrane spanning domains and three *pstS* substrate binding domains, all encoding different parts of the Pst system. For our experiments we used the *pstA1* transposon mutant as well as an unmarked in-frame deletion of *pstS3*.

Inorganic phosphate is an essential nutrient and may be limiting in the macrophage phagosome as a part of the host defense.

In order to demonstrate the importance of the Pst system to *M. tuberculosis* virulence, we examined the replication of *pstA1* and *pstS3* compared to the wild-type (WT) strain in mice.

The *pstA1*and *pstS3* mutants demonstrated reduced virulence as compared to the wildtype strain (Fig 1), concluding that the Pst system and our mutant genes, *pstA1* and *pstS3,* are essential components to Mtb virulence.

We conducted two different experiments to further explore the mechanisms behind the importance of the Pst system, growing the WT and mutant strains in low phosphate media to maximally induce Pst activity.

In a radioactive phosphate uptake experiment, the results have shown that while pstA1 takes up phosphate less quickly than the WT strain, *pstS3* has no defect. *PstS3* is highly homologous to *pstS2* and we hypothesize that *pstS2* is able to support phosphate uptake in the absence of *pstS3*.

In contrast, *pstA1* and *pstA2* share limited homology and may not have the same degree of redundancy in uptake capacity.

In previous studies, it has been demonstrated that *pstS2* mutants cannot take up phosphate at low phosphate concentrations. This suggests that *pstS2* plays an important role in phosphate uptake, and that *pstS1* or *pstS3* mutants can't take up phosphate in low P_i concentrations without *pstS2*.

Using RT-QPCR, we observed that the *pstS2* gene is expressed more than the other genes in both high phosphate and limiting phosphate conditions (Fig. 2).

The genes appear to be

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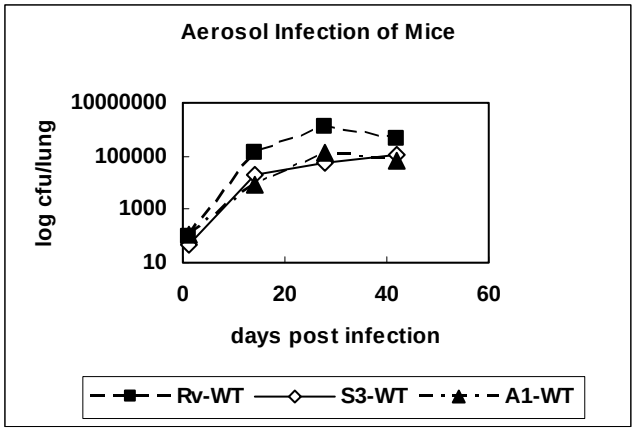

Fig. 1. The *pstA1* and *pstS3* mutant strains have decreased growth as compared to WT bacteria in mice infections.