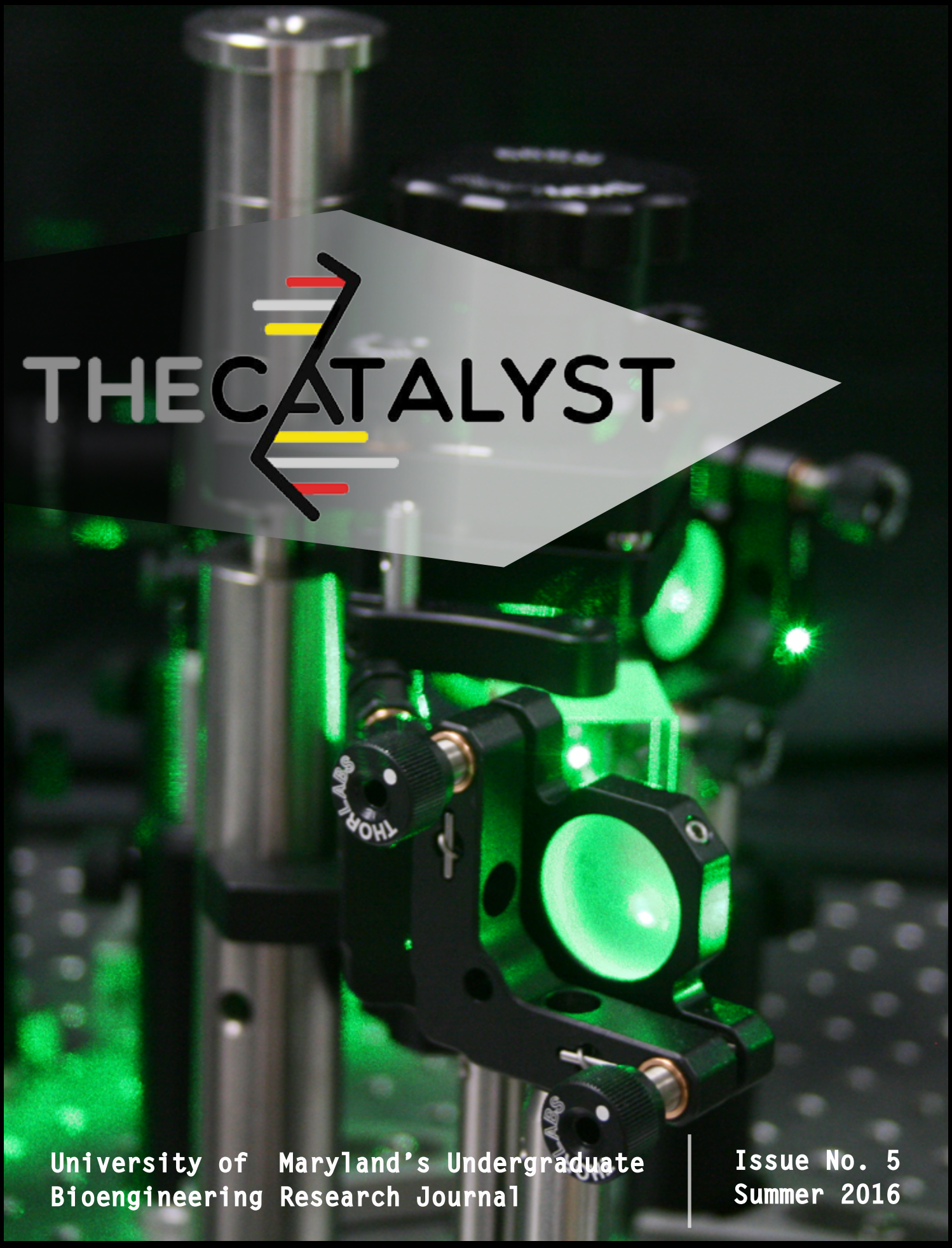
THECATALYST
University of Maryland's Undergraduate
Bioengineering Research Journal
Issue No. 5
Summer 2016

Want to get published in the next issue?

THE CATALYST

The Catalyst is UMD's undergraduate bioengineering research journal. We are looking to publish a variety of related undergraduate research with our sixth issue coming this Winter 2016! If you are an undergraduate student working on research related to bio-medical engineering and biotechnology, you are qualified to submit a research blurb. Contact us via email or submit your research abstract through the link provided below. Please check out our previous issues as well.

No research experience?

You can still take part in *The Catalyst's* News Updates sections, which showcases top-ics such as recent BioE student events. Email us if you are interested in contributing.

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IN THIS ISSUE

Letter from the Editor

Hello *Catalyst* Readers,

Welcome to our 5th issue! With each successive semester, I think that *The Catalyst* has gotten significantly better, and I am excited to present our newest issue. I truly believe that we are improving with each issue. This issue brings fresh designs, exciting new stories, and the research blurbs that we hope will galvanize student research in bioengineering and biotechnology. For the first time this semester, we present blurbs from two people who did bioengineering research but are outside of the major. Bioengineering research is extremely interdisciplinary, as Delaney Jordan and Brian Heligman explain. Articles from current bioengineering students Jessica Yau, Tom Mumford, and Natalie Livingston are also contained within this issue. Although all of the researchers that we highlight do bioengineering research, it is easy to see how diverse the field is. From biomedical optics to drug delivery to biosensors for detection of small molecules, we do it all. In addition to the great researchers that we highlight, there are also spotlights on a capstone project that is redesigning the thermal cycler, the motivation behind the new curriculum, an interview with the new department chair, the Alumni Cup competition to build a Rube Goldberg machine, and the 4th annual UMD-JHU BMES Research Competition. On behalf of the editorial team, we are excited to share these research blurbs and news items with you.

Although the articles are getting better, the digital design is improving, and the research blurbs are becoming more accessible, we will be missing a very important member of our current team next year. As the original founder of *The Catalyst* moves on to pursue research and medicine, I want to take a minute to reflect on his great leadership in founding *The Catalyst*. Kevin Pineault has been not only a great friend to me, but also a great mentor to many. Although he initially came up with the idea for *The Catalyst*, he never treated it as solely his own. He always listened to what others had to say and allowed collective group dynamics to define what it should and should not be. It has evolved over time, but Kevin's original idea of giving students a place to share their love for research and to encourage students to get involved in undergraduate research still stands true today. Our mission has not changed. It is bittersweet to see Kevin leave, but we are excited to see what amazing things he will do in a new issue of his own life. Moreover, we are excited to see where the newest members of our editorial team, Havisha, Maryam, Justin, and Morgan, will take this publication in the future. Additionally, we cannot wait to see more of the great design that Ashlyn is bringing to *The Catalyst*.

In the one year that I have been Editor-in-Chief, so much has happened here in the Department of Bioengineering and on campus. Undergraduates are doing great things in research all around us, and it is really humbling to see everyone's accomplishments. I have enjoyed being Editor-in-Chief of *The Catalyst*. Next year, I am excited to take a step down, allowing a new leader to emerge. Although I plan to be just as active in the group, I think that bringing fresh ideas to the table will only be advantageous for our publication. Thank you to a great editorial board that is enthusiastic and excited to bring ideas to fruition. Please turn to the last page to learn more about all the great people that make this possible. Finally, thanks to you, our dedicated reader for looking at our publication.

Enjoy the Issue,

Adam Berger
The Catalyst Editor-in-Chief

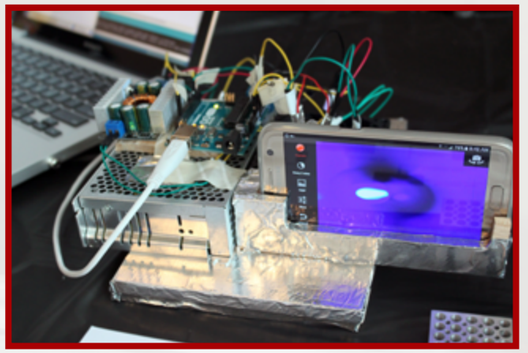
Capstone: Building a Cheap PCR Machine

Highlighting one team as they seek to amplify their Capstone Project

By: Aditya Biswas, Guest Contributor

Designing a thermocycler for polymerase chain reaction (PCR) is not in and of itself a difficult task. A person can simply prepare three baths of water and heat them up to three different temperatures, 95, 70, and 40-50 degrees Celsius: 95 to split apart DNA, 70 to enable polymerase enzyme to add nucleotides, and 40-50 to enable the polymerase to bind. A person can move tubes from one container of water to another to enable each of these steps to occur. The challenge lies in making this process faster without consequently making it more complicated or expensive. Our capstone team has designed a method to achieve this automated thermocycling in both a fast and inexpensive package. By using ceramic heating elements, our device can heat up our tube to the desired temperatures and our high flow fan can rapidly cool it back down. This closed loop control system has enabled us to achieve automated thermocycling.

However, an automated thermocycler by itself is still not a major advancement to science, as it simply amplifies the DNA quantity. Although our design is 400 dollars less than the current open-source PCR machines, regular PCR machines are a dime a dozen and relatively cheap, making our device unremarkable. To fix this, we added additional functionality to measure the amplification amount. Our machine has thus become remarkable in its ability to be a cheap real-time PCR machine. Capitalizing on the eight megapixel camera of smartphones, we were able to capture DNA amplification in real time within our machine. Although we are still in the preliminary stages of testing our device's real time capabilities, if successful it has the potential to reduce the price of qualitative PCR 100 fold. The current cheapest machines cost around 30,000 dollars, while ours will only cost 200. This reduction in price will enable the PCR machines to be utilized in the developing world, an area that could benefit from the rapid diagnosis of diseases, such as Ebola and Zika viruses.



ALUMNI CUP 2016

A Dramatic Overview

By Kenneth Ke, Guest Contributor &
2016 Team Leader

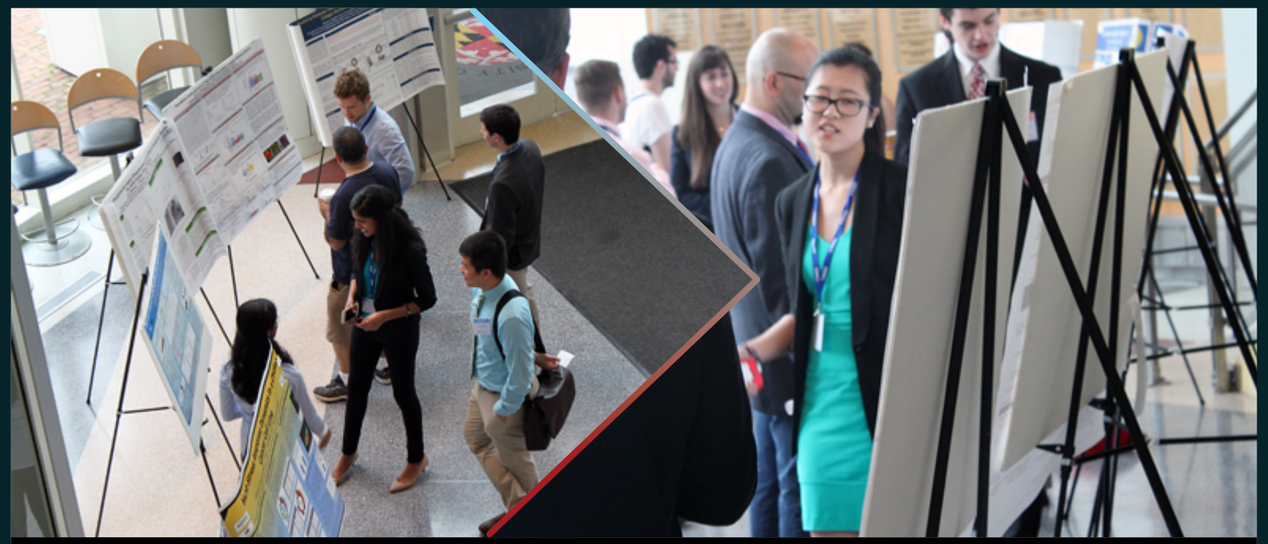
It was a dark and stormy night as the first real spring storm was blowing into College Park. Yet, as the first raindrops fell, eight fearless bioengineers were converging on the Animal Science building with passion in their heart and pencils in their hands. Their mission was handed down directly from the Alumni Association: to create a Rube Goldberg machine and outshine Aerospace. To out-design Mechanical. To show ECE how it's done. To smoke Fire Protection. To outwit Chemical, and to crush Materials. So we began, with $120 in our pocket, and our minds teeming with ideas and designs. As Dr. Frankenstein had, our noble yet dastardly plan to create Team ZomBIOE: enhanced undergraduate students who were Rube Goldberg building monsters. As Team Bioengineering designed and constructed with a fervor never before seen within the Fischell Department, the ZomBIOEs emerged as a force to be reckoned with. It was an eruption of commotion from the very beginning and the passion was palpable as it permeated the atmosphere. It was an amazing work environment, where we could strip away titles of seniority and preconceptions of superiority and have a truly open dialogue where every idea and every person was respected. It was a commitment of nearly 30 hours from undergraduate engineering students who hardly have a minute to spare between clubs, classes, studying, and extracurricular commitments. But the ultimate rewards of working on the Alumni Cup Team were worth every minute invested. It was a chance to truly work as a team to accomplish a goal, to practice the fundamentals of engineering outside of a classroom, and to watch as something that started within our minds turned into a tangible construct. To create a bond between passionate engineering students. I loved working as a member of Team ZomBIOE and am excited to crush whatever they throw at us next year. #BioEforthecup2017

#BioEforthecup2017

Why Should You Join Next Year?

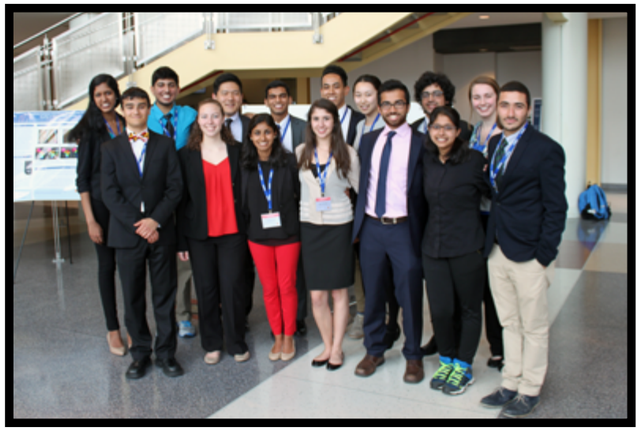
By Justin Sylvers, Staff Editor &
2016 ZomBIOE Team Member

As an undergraduate student, an engineering major and just a general fan of cool things, the Alumni Cup was an invaluable experience. But why should you join? Sure, you get to put the fundamentals you've been learning into practice. You even have the opportunity to transfer something from the ether of your mind into the physical plane. Although there is nothing quite like that, I would argue that the most valuable part of participating in this competition is the opportunity to meet and form relationships with people in your major. The Alumni Cup is about interacting with those peers that you may have never seen before. You'll meet people who have stood where you stand, struggled with the same classes and made it out on the other side. You'll meet upperclassman mentors who will convince you to go to a career fair despite being severely underprepared, offering you a suit jacket as they cram facts about Medimmune into your brain (and yes, I speak from experience). You'll sit around with your newfound comrades in arms, brainstorming, eating, building and troubleshooting until it's 3:00 AM and you find yourself wondering where the day went. It's that networking that everyone is always advertising as the best way to get ahead, and get this... it's actually fun. Don't let your dreams be dreams. Join the 2017 BIOE Alumni Cup team. #BioEforthecup2017



TERPS vs BLUE JAYS & BLUE HENS

by Dani Mahsan Khalilzadeh, Staff Editor



For the past 4 years, the University of Maryland Bioengineering and the Johns Hopkins University Biomedical Engineering departments have teamed up to hold an annual research competition. This year, the University of Delaware Biomedical Engineering department joined the mix. The event was planned and organized by the Biomedical Engineering Society (BMES). Students from various bioengineering labs at UMD sent in abstracts to BMES for review by a committee of UMD BIOE professors. From the group of abstracts submitted, three were selected for oral presentations and the others were selected for posters.

Every year, the competition alternates between the two university campuses. This year, the competition was held in the Kim Engineering Building on Friday March 25. Students from both campuses showed up in support of their classmates.

UMD Bioengineering Junior, Nadia Alam described her experience:

"The atmosphere was so engaging. Normally in any situation where there's a large group of people I have never met before, I wonder how I can start conversations. It would seem even more difficult when half of the people there are from another university altogether. At the competition, however, breaking the ice was as easy as asking 'What did you work on?' People were as friendly as they were knowledgeable, so conversations turned reciprocally enthusiastic as we shared what we were up to in the lab, and even other aspects of student life. It was a great experience and I got to speak to many different students and learn a lot about their projects. I received encouragement before presenting from not only UMD students, but the JHU students I spoke to before the as well. I found that the overall attitude of the students at the competition was one of enthusiasm in both sharing their research and learning about the work of others, and it was a great experience."

This year, JHU took the first place trophy. The best poster award was given to BaDoi Phan of Johns Hopkins University for his research on "Transcriptome Analysis of Pitt Hopkins Syndrome in a Murine Model". The following students won for their presentations:

1st Place: James Shamul (JHU)
Research: Doxorubicin-Loaded Amphiphilic Poly(β-amino ester)–Poly(ethylene glycol) Block Copolymer Micelles for Cancer Therapy

2nd Place: Joshua Kim (UMD)
Research: A strategy to avoid phagocytosis of drug nanocarriers by macrophages without affecting receptor-mediated endocytosis by specifically targeted cells

3rd Place: Alexandra Berges (JHU)
Research: Identifying PET Activation Biomarkers to Predict the Conversion of Mild Cognitive Impairment to Alzheimer's Disease

Congratulations to everyone who participated in this year's competition! We are looking forward to next year's competition at JHU where the Terps will for sure take the first place prize!

MOTIVATIONS FOR THE NEW CURRICULUM

by Havisha Garimella, Staff Editor

As the University of Maryland's Bioengineering department continues to grow, so has its curriculum, which was changed this year by the department. The main components of the curriculum change include choosing 2 out of 5 BIOE foundational courses ("selectives"), removing 2 required courses and the 2 engineering electives, and adding 4 BIOE electives. This spring, juniors were asked to decide between remaining on the old curriculum or switching to the new one. Current sophomores and freshmen who matriculated to the department prior to Spring 2016 also have the option of staying on the old curriculum or switching to the new curriculum.

Dr. Tracy Chung, Director of Academic and Student Affairs, gave insight as to why the curriculum was changed. She said,

"If you really look at the nuts and bolts of the changes, they aren't that dramatic. It's not like as if there is a big shift with philosophy in the department. The reason why we weren't able to implement this curriculum structure before was because we really didn't have enough faculty to commit to teaching enough electives."

When the department started, it was rather small. This meant that the department did not have their own professors to teach some of the core BIOE classes; bioengineering students had to take essential courses, such as fluids and thermodynamics, from the other engineering departments. Fast forward to 2016, and the bioengineering department has now grown to a size where they have enough faculty to teach core classes. As Dr. Chung said, "Once those were covered, then we can keep growing and hiring faculty. Now we can branch out and offer specialized electives, which is really what people want…This has always been the plan, so we are just really at a point where we can implement more reliably with these types of operations."

Students who have the option of switching may still be wondering what curriculum they should choose to follow. Dr. Chung believes that "they shouldn't be deciding. It's no question. They should be on the new curriculum. It's just a better version of the old one." However, if students do decide to remain on the old curriculum, there should be strong reasons for doing so. On the other hand, the old curriculum does give students more space to take engineering electives from other departments (i.e. it reserves 6 credits for ENGR electives and 3 credits for Flex electives). Students may be wondering if the old curriculum would be better suited for those who want to take non-BIOE electives. She responded,

"One reason why we took the focus away from other department electives is because our students can't get into them. You know it's really hard to get into a MechE elective, if not impossible. So that's why we made the requirements such that there are 4 BIOE electives. It's not to prohibit you from taking those other electives but it's just because they usually aren't available to you."

However, she did say that students who do wish to take a course from another engineering department can take it to satisfy the 3 credit Breadth elective requirement. Also, exceptions can be made for elective substitutions if approval is granted by the track leader. Even students considering adding a minor should still consider following the new curriculum because additional courses would have to be taken regardless if they were on the old or new curriculum. "And the most important thing is what you're getting for your degree, not for your minor. As long as your degree makes sense, you shouldn't water down the bioengineering degree in order to fit in your minor."

The BIOE tracks, as part of the new curriculum, will enable students both to specialize their studies and better sell themselves to employers.

"Each of the electives in the tracks is intended to give the students skills and help you talk about a skill set within that track. Another thing the tracks are supposed to do is build community. Students can have a little bit of an identity around these tracks by going to speaker events and learning from possible job opportunities, or sharing experiences of internships, you know, and connecting with alumni."

"This has always been the plan, so we are just really at a point where we can implement more reliably with these types of operations."

Additionally, transport, which was required by the old curriculum, has now become optional. Although it has become optional, students should still definitely consider taking the course.

"Transport is a required course for the biotech track [Biotechnology and Therapeutics Engineering track] and it's also an optional course for any of the other tracks…There is nothing to be afraid of in transport! And what it does really provide you is math prowess that other people aren't going to have. So if you want to come out of here and say 'yeah' I've got this asset. I mastered it, and I can go out to the real world and do high level math or advanced level things that other engineers may not, then you should take it."

A lot of the faculty members have taken the class at least once during their undergraduate and graduate school studies. Dr. Chung also offers encouragement, concluding that "I think also what's going to happen with transport, since it will be a smaller class, it may be a better experience."

All in all, there may be many factors to consider when deciding which curriculum to follow; however, know that faculty members and advisors are available to for guidance, and they can make the process less overwhelming.

OUTSIDE THE CLASSROOM:

An Interview with Dr. Fisher

by Kevin Pineault, Research Chair, and Bryan Pinksy, Staff Editor

As an undergraduate at Johns Hopkins, he took classes for both chemical (ChE) and biomedical engineering (BME). By graduation, he picked ChE for my degree. He also took 3-4 art history classes for my humanities course requirements. We got interview to welcome him as the new department chair.

As a chemical and biomedical engineering major, what mentorship and experiences as undergraduate lead you to pursue a Ph.D.?

Chuckles I didn't get a lot of mentorship as an undergraduate. I had a challenging time. Doing two majors was a poor decision and I was struggling most of the time. I did not get a tremendous amount of mentorship or advising. After Johns Hopkins, I was planning to move back to my home in Ohio, and I was lucky enough to get into a Master's program at the University of Cincinnati. It was only when I started the program there that I discovered that research was interesting, fun, and that I wasn't too bad at it. My Master's was focused on biomaterials for drug delivery and is what got me started in tissue engineering.

To go from there [Masters Program at University of Cincinnati] to a faculty position would have been really challenging, even with a couple papers and the recent success I was having in research. My mentor suggested I should apply to the top Ph.D. BME programs. After our discussion and deciding to apply, I got into Rice and decided to go there, where my Ph.D. adviser was one of the founders of tissue engineering.

After Rice, what brought you to Maryland?

I interviewed for positions the spring of 2002, and I chose Maryland in April of 2002. Surprisingly, I didn't actually finish my Ph.D. until October of 2002, and then I did a post-doc from November of 2002 until August of 2003 - so I interviewed before I finished my Ph.D. At the time, this was somewhat common in ChE, where you could interview for a faculty position before you completed your Ph.D. The benefit of this is that it would give you time to go complete your Ph.D. and maybe a post-doc. Now, it is so competitive to get a faculty position that people can have many papers under their belt, one or two post-docs, and their own grants; the people we hire now are infinitely more sophisticated than I was. Now, just like everything else – getting into college, getting into graduate school – securing a faculty position is much more difficult.

Was there anything in particular about the University of Maryland that made you decide to come here?

At the time in the early 2000s, tissue engineering was popular, but Maryland was just thinking about moving into bioengineering and already had a very strong engineering school. I felt like if I came to Maryland, since I would be the only person in the tissue engineering field, there would be a lot of infrastructure in engineering, and I could make a big impact into bioengineering and tissue engineering.

What was it like starting your own lab?

A few chuckles There was no one in the school of engineering I was aware of that was doing cell culture. I started in 2003 in ChE, and the first time I ordered rats, everyone around was surprised and there was no one close by to ask for help. The closest lab in terms of research was Dr. William Bentley's lab which focused on bacteria culture, but he did not conduct work with eukaryotic cells. Now, there is a huge amount of infrastructure to support tissue engineering, cell culture, and bioengineering work in general. However, I like doing my own thing, that appeals me, so I thought the entire process was great.

Could you explain your approach to research? Is it more hypothesis driven or exploratory?

When we got started, we had a few ideas to try to understand things better; how matrices would impact cellular response and cell-to-cell communication. Slowly I realized, it was a hard story to sell. We had a lot of information, but people wanted to know what tissue we were going to engineer. About 8 years ago, our lab shifted to having each student build something - a bioreactor, a new material - build something. The first set of studies were then to design and create new things, and the subsequent set of studies focused on understanding the phenomena that underlie how it works. From there, you can propose different hypotheses. For example, a scientist we work with a Children's National Medical Center is specifically focused on bioprinting a placenta. Other students have worked on 3D-printed vascular grafts and bioreactor chambers, separately. They build it and try to understand the underlying phenomena. Investigating new devices, materials, or bioreactors has seemed to be more successful for both publications and securing research funding.

We still need clear clinical impact to drive the field, but we also need people to be thinking ***outside the box*** *so as to create the strategies that will be successful 10+ years from now.*

What problems do you think can be addressed by tissue engineering in the next decade?

Scientists and engineers will continue expanding the field's boundaries. The field has had some successes already, and these successes will allow for future growth. We still need clear clinical impact to drive the field, but we also need people to be thinking outside the box so as to create the strategies that will be successful 10+ years from now. Within the next 5 to 10 years, I could see cell-laden constructs becoming a widespread clinical reality. This would involve taking a cell population, putting it in a biomaterial, and implanting it into an organ for treatment.

What is your advice to current students?

Do what you are most excited about. That is what you will do the best in and give you the most options. It is hard to know exactly what you want to do in the future. However, if you find something you really enjoy or love doing, I think it is more worthwhile to pursue. For example, I and my three sisters went to college and a couple of us went to graduate school. My brother played basketball in college and did not follow a traditional route for developing a career. However, he now owns a very successful company with hundreds of employees and operates in over six states. You never know what will happen, so do something you enjoy!

STUDENT RESEARCH

Bioengineering meets Materials Science and Engineering

by Delaney Jordan, Guest Contributor

Last year, I worked in the MEMS Sensors and Actuators Laboratory (MSAL) at UMD and got to experience the intersection of Bioengineering with my own major, Materials Science and Engineering. A previous internship in a cleanroom laboratory had gotten me interested in the fabrication of microelectromechanical systems (MEMS) devices for bioengineered applications. Before working at MSAL, I only knew how microprocessing could be applied in electronic sensors for radios and computers, but by trying something new I got to see how the same technology is used in biomedical applications.

Within MSAL, I worked on building a sensor to detect the concentration of clozapine in the blood. Clozapine is one of the more effective drugs available to treat schizophrenia, but its use places a large burden of care on the patient in order to monitor and ensure that the dosage is within a safe and effective range in the blood. For this reason, it is underutilized as a treatment in the U.S. Making a portable sensor to monitor clozapine blood concentration would allow the use of this drug in more situations.

Constructing such a sensor is a difficult task to approach because there is no known protein that selectively binds with clozapine. This means that the detection must be done electrochemically, by looking at how the electric current between two electrodes changes (relative to a reference electrode) as a function of clozapine concentration in a blood sample. This happens using similar chemistry to a battery: a redox reaction occurs at one electrode, and depending on the identity of the molecule being oxidized or reduced, a different signal is detected by the other electrode. There are, however, more species in human plasma other than clozapine, such as acids produced by the metabolic breakdown of food, that also produce an electrochemical signal that is detected by the electrode. Therefore, I worked on analyzing the electrochemical signal from these interfering species in order to characterize a background signal that will be subtracted to isolate the clozapine signal.

In order to find this signal, I used a gold working electrode (where the redox reaction occurs), a platinum counter electrode (where the signal is detected), and a silver/silver chloride reference electrode. First, I polished the Au electrode to ensure it was scratch-free and therefore had exactly the surface area that was expected. I attached all three electrodes to a potentiometer and verified that the gold surface was well-polished by performing a cyclic voltammetry scan in ferro/ferri-cyanide solution and verifying that the resulting current vs. potential redox curve matched the standard curve for a well-polished Au electrode. If there was any significant difference between the two scans, I had to re-polish the electrode.

Next, I changed out my ferro/ferri solution for one containing a particular electroactive interfering species that is present in human plasma--such as uric acid--at a concentration typical of what is found in the bloodstream. I ran the same cyclic voltammetry scan, and saved the resulting data for future analysis. Because of the reaction products that foul, or clog, the electrode, I repolished the electrode and started the process over every few scans. When I had done enough trials with uric acid solutions, I moved on to characterize the signals from other interfering species. The next step, if I had more time at MSAL, is to measure solutions containing more than one interfering species, and finally to measure solutions of interfering species and the drug clozapine. This final step will enable the future sensor to look at a cyclic voltammetry scan of human plasma and determine what concentration of clozapine is in the blood, despite interference from other electroactive species present.

My work at MSAL was very different from my previous jobs, and I got to see how the technology I was familiar with (microprocessing fabrication on wafer substrates) was used in an application I originally considered to be outside of my field. Although I was working on the electrochemical testing for the project, the sensor itself will be made in a cleanroom using the same microprocessing techniques that I had used at my previous internship. I got to see some of this fabrication while I was at MSAL and realized that because I took an internship that was outside of my comfort zone, I learned how real research is multidisciplinary. I was a materials engineer working in a bioengineering lab, and I know there have been chemists and electrical engineers before me who had to develop the very tests that I was using to take data. Even the sensor itself is something that will support medical professionals who treat schizophrenia patients.

I now believe that every student should take at least one internship that is outside of their major. At the end of the day, you are most likely to be one engineer on a team of all types, and it's good to understand what your discipline brings to the table. College is the best time to do this, because you're expected to explore and find out what you do--and do not--want to do. Furthermore, nobody has much experience, and as long as you have a good work ethic, most jobs are happy to take you on and train you up. I am very grateful that I had the opportunity to work at MSAL, because of what it taught me about my field, and about myself.

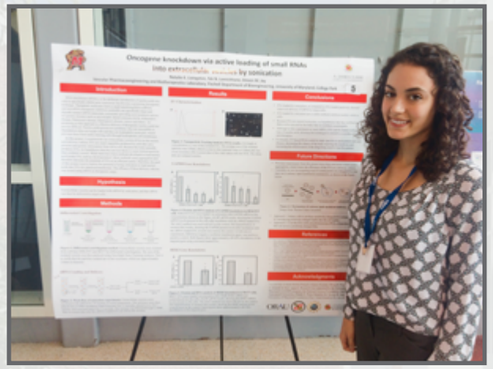
Delaney works in the clean room and sees her reflection in a wafer.

Loading Extracellular Vesicles for RNA Interference

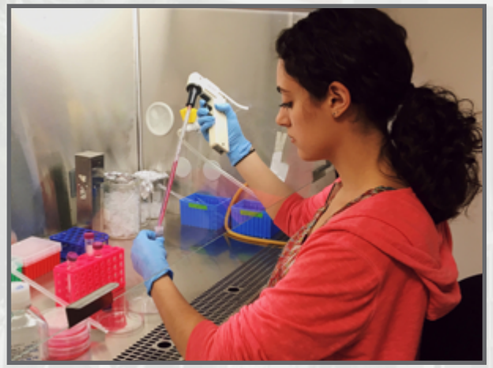
by Natalie Livingston, Guest Contributor

RNA interference (RNAi), or the deliberate introduction of nucleic acids into cells specifically to inhibit gene expression, has become a promising therapeutic technique. Therapeutic molecules such as small interfering RNA (siRNA) and microRNA therapeutic inhibitors (antimiR) can specifically target and degrade mutant mRNA transcripts, potentially providing new treatment options for genetic diseases such as amyotrophic lateral sclerosis (ALS), Alzheimer's disease, Parkinson's disease, Huntington's disease, cancer and others. As promising as this approach is, effective delivery of therapeutic nucleic acids has proven difficult. Nucleic acids present two problems: they are susceptible to degradation outside of cells and they are hydrophilic molecules, which prevents them from easily entering cells through hydrophobic cell membranes. Thus, the development of new, efficient, and stable delivery methods for nucleic acids to reach the inside of cells is necessary.

In my research, I work with small organelles called extracellular vesicles (EVs). EVs are nanoscale lipid molecules that naturally function in the body to deliver proteins and genetic information from cell to cell. Previous research has shown that EVs have promise as delivery vehicles; however, they may not be highly efficient due to low amounts of incorporated nucleic acids. As a result, one cell may have to take up many EVs to ensure a biological response. Therefore, I am testing various methods of loading EVs with nucleic acids to improve their efficiency and efficacy. By maximizing the content of nucleic acids for RNAi inside of EVs, we can promote greater therapeutic impact at lower doses, which also has the benefit of limiting potential side effects. Once fully developed and tested, this approach has the potential to be applied clinically in personalized medicine, as EVs could be extracted from each patient, loaded with the appropriate RNAi to target the patient's abnormal genes, and then reintroduced into the body to stop the transcription of aberrant DNA. Eventually, EV-based RNAi could be made specific to each patient and each disease, decreasing the chance of the body rejecting the medicine and increasing the effectiveness of the drug being used to treat the patient.



Natalie presents her poster on using sonification to load RNA into EVs.



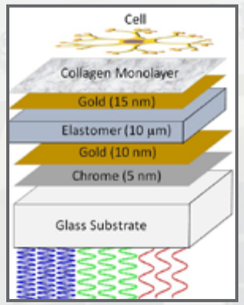
Natalie works hard in Dr. Steven Jay's lab to research the most effective methods for loading EVs.

I have been a part of Dr. Steven Jay's lab for 7 months now and I can honestly say it has been one of the most rewarding experiences during my time here at UMD. I highly recommend getting involved in undergraduate research. Even if you are not interested in a career in academia, research opens so many doors for you. You learn skills that look great on resumes, you show potential employers that you are motivated and experienced, and there are plenty of opportunities to get paid for your time! To anyone interested in research, start emailing principal investigators (PIs) right away. Don't be intimidated by professors; they love talking to students who show an interest in their research!

Fourier Transforms for a Brillouin Spectroscopy Sensor

by Tom Mumford, Guest Contributor

Working in the Biotech Optics Lab is a more challenging, engaging, and rewarding experience than I could have ever imagined. It started with a simple email. After a new BIOE professor, Dr. Scarcelli, gave an exciting guest lecture in my Biology for Engineers Lab, I knew I had to reach out to him. He agreed to give me a shot working in his lab during the remainder of the spring semester, and I received an ASPIRE engineering research grant through MTECH in order to continue working there during the summer.

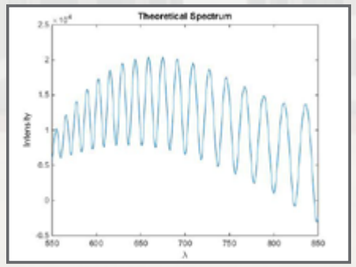


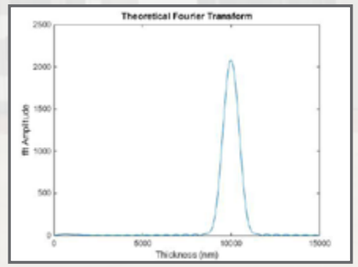
The major focus of the Biotech Optics lab is Brillouin Spectroscopy, a technique that uses light to noninvasively determine the mechanical properties of a material. This is especially useful for testing biological samples that can't be measured using conventional methods, which require the sample to be removed and stretched by a machine. When I joined, our lab had just begun working on a collaboration with a lab in Scotland. They had developed a sensor for measuring cellular forces. The goal of the collaboration was to combine our two technologies to develop an instrument that could measure exerted cellular forces and cellular stiffness simultaneously. This could elucidate a variety of cellular mechanisms that are still unknown, including the growth of neurons and the metastasis of cancer cells into blood vessels.

The sensor is comprised of several layers of material; two gold layers surrounded an elastic layer. Cells placed atop the sensor deform the elastic layer in accordance with the forces they exert. By shining light into the sensor from the bottom and measuring the back-reflected light, we could determine the thickness of the elastic layer. This was possible because when the thickness between gold layers was a multiple of the wavelength of the input light, resonant waves would become trapped between the layers. This could be seen as a minimum in the output spectrum. Using the material properties of the elastic layer along with the deformation caused by the cell, the cellular forces exerted on the elastomer layer could be calculated.

The researchers in Scotland had already designed the sensor, but an effective and accurate analytic method to calculate the thickness of the sensor from the output spectra was still needed. I used MATLAB to create such a method over the summer. I accomplished this by developing a Fourier transform-based program to analyze the signal output of the sensor. A Fourier transform takes a signal with domain t and returns its frequency, 1/t. By mapping our signal, which was dependent on wavelength, to a domain of $1/\lambda$ and then taking the Fourier transform, we could determine the thickness of the sensor in nanometers. In order for the Fourier transform to output accurate readings, the signal had to be highly processed.

Despite being unfamiliar with MATLAB, I was able to learn on the job and get accurate readings by the end of the summer. Although the summer was totally different from what I expected, I would not change a thing about it. I learned a good deal about optics, physics, coding, and the research process in general. To any undergraduates looking to get involved in research, my only advice is to find a professor whose work excites you, and send them an email conveying that sentiment.





▲ *Tom Mumford and his lab.*

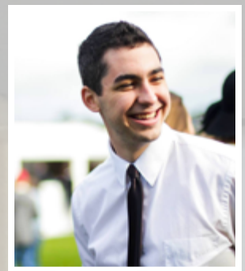
▶ *Schematic of sensor used in Tom's work.*

◀ *(far left) Output spectra used to calculate thickness of sensor.*

◀ *(middle left) Result of Fourier transform-based program to determine sensor thickness.*

From Design to Device: The Development of an Ammonia Sensor

by Brian Heligman, Guest Contributor

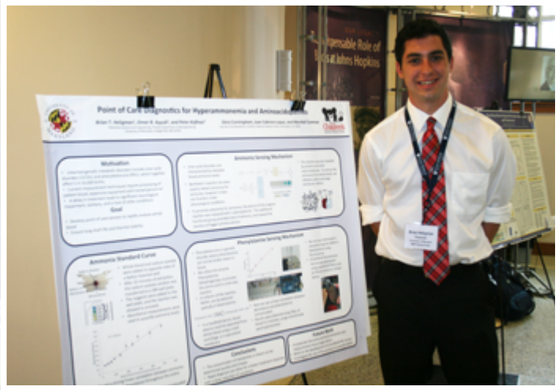


I began my bioengineering research with Dr. Peter Kofinas during my freshmen year, with absolutely no idea what I could expect. However, during my time in his lab, scientific research would grow from an interest I worked on a few hours per week, into a vocation which still permeates my outlook today. Development of our first device, a point of care blood sensor, taught me about the crux of scientific research: careful experimental design followed by rigorous data analysis. While I deeply value that understanding, it was the further evolution of that sensing scheme into a functional prototype and undergoing clinical trials that truly crystallized my passion for applied research. I love the potential impact that results from the coupling of the deep understanding required by pure sciences with the systematic design and optimization that define engineering.

Prof. Peter Kofinas was one of my first teachers in the fall semester of freshman year. I learned that he had also studied Materials Science, and we started to talk about scientific research. He told me he was working on a sensor for blood ammonia levels, and asked me if I wanted to help him develop the device. I quickly learned that some newborns suffer from genetic disorders preventing proper metabolism of ammonia, and delays in treatment result in severe mental impairment. While the current diagnostic techniques required trained personnel and advanced equipment, he felt a sensor could be made that would operate quickly, simply, and cheaply. My first task was to build the electronic portion of the device.

In our device, ammonia was extracted from blood across a polymer membrane, and quantified using a colorimetric reaction. The innovation in this scientific approach was the use of the polymer's negatively charged pores to inhibit passage of proteins and other large molecules, resulting in reduced interference and increased specificity. I built a spectrophotometer for the device, and began designing wells for the extraction. I learned CAD software quickly, and sent off a design to be 3D printed. Within a week, I was holding the component I had designed! It was terrible; looking back on it today, the design still makes me laugh. Measurements taken using the wells I eventually developed would be the basis of my first publication.

Upon returning to UMD after a semester in Sydney, Prof. Kofinas and I prioritized development of the ammonia sensor. We realized that a microfluidic chip would best accommodate the four separate reagents required by the reaction, and I took point on the creation of the chip. I modeled different systems in COMSOL to ensure sufficient channel mixing, and subsequently produced my design. After we finally developed a working prototype, we began working with our partners at Children's National Medical Center to create a company that would manufacture and distribute the system. As clinical trials began, seeing patients directly benefit from my work solidified my belief in the philanthropic potential of research. As the device continued to evolve, alterations were made not for increased performance, but to allow realistic implementation. The further development of my academic idea into a real product has been an invaluable experience, one which I will certainly draw upon in the future. I presented my work at the 2015 UMD-Johns Hopkins undergraduate research competition and received 2nd place. The final device is currently expected to be available by mid-2017.



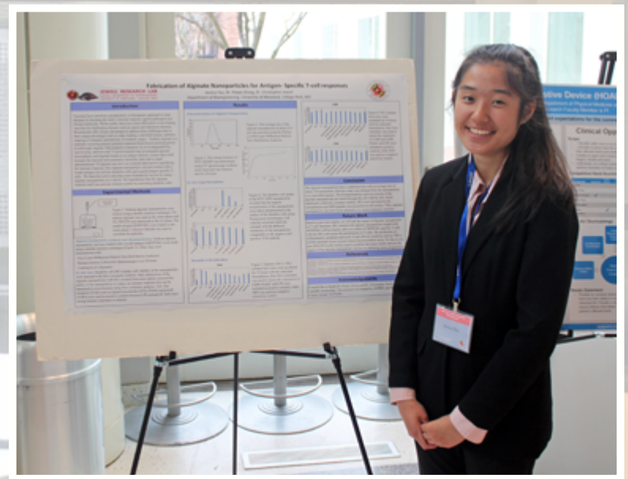
Brian presents his poster, "Point of Care Diagnostics for Hyperammonemia and Aminoacidopathies".

Alginate Nanoparticles for Therapeutic Vaccines

by Jessica Yau, Guest Contributor

Doing research has been an adventure of learning. My research experiences began at the National Cancer Institute where I worked on finding alternative pathways of the Parkin pathway such as inducing mitophagy by using different siRNAs to treat Parkinson's disease. From then, I fell in love with the ability to use research to explore and discover different biological phenomenon that could make a difference in someone's life. Conducting a research project is comparable to writing a story. There are people involved in the story and there is an overview to the particular field of research, a plot as you venture through research, and a conclusion that ties all the components together. Starting my freshman year in the spring semester, I have worked in Dr. Jewell's lab where I have learned the stepping stones towards developing and carrying out a research project. My research project is on therapeutic vaccines – vaccines in which the immune system is harnessed to treat diseases such as cancer. In Dr. Jewell's lab, new biomaterials-based vaccines have unique properties such as biodegradability, targeting, and loading of multiple cargos for next generation vaccines which serve as therapeutic vaccines. In addition, these biomaterials provide opportunities to address challenges by generating potent responses against specific molecules – termed antigens – while tuning the characteristics of these responses to combat a target disease. The mentors have provided invaluable advice and guidance from searching literature reviews and articles to acquire a greater understanding and to start branching into a research field that was new to me.

This particular project develops a new vaccine composed of biodegradable alginate nanoparticles and a model antigen via a double emulsion technique. We hypothesized that alginate materials can be harnessed as an adjuvant – a signal that amplifies the immune function – while SIINFEKL carried within the particles can generate an antigen specific T-cell response against this peptide. A series of experiments were carried out to test this hypothesis. There were obstacles and challenges. Thinking around the problem and approaching the solution in a different method inspired me. At the end, alginate nanoparticle vaccines were found to activate dendritic cells and expand antigen specific T-cells when SIINFEKL antigens are loaded in the particles. Moreover, the alginate material that composes the vaccine can serve as a natural adjuvant for amplifying the immune response. Coupled with an activated immune response maintained through booster vaccines, residual diseases can be patrolled over an extended period without significant toxicity to the patient or a lengthy time commitment. This work could lead to novel carriers that not only can serve for the delivery of cancer vaccines but also help stimulate more effective and safer responses due to the natural properties of alginate. Being able to make this impact on the community has inspired me to continue my interest in research. These experiences have taught me how to think logically and how to harness different methods and materials to create an impact on human health and life.



Jessica showcases her work in a poster titled, "Fabrication of Alginate Nanoparticles for Antigen-Specific T-cell Responses".

A LOOK BACK:

What inspired you to be a bioengineering major?

RL: I was interested in brain-controlled interfaces when I was younger for its military applications.

JY: I always liked math and wanted to do something medical, so bioengineering seemed to be the best combination of the two.

NC: I always had a love for math and science and figured bioengineering would be a good mesh between the two.

SB: I liked biology a lot in high school, and I also wanted to be an engineer and design things - hence, bioengineering.

MR: The ability to build/solve problems in biological systems and improve the world around us using biological solutions is what most inspires me to be a BioE student.

What is your dream career within BioE?

SA: Becoming a surgeon, working with fabricated bio-materials!

RL: Definitely want to involve computer science in my career. Maybe get involved in the industry or pursue bioinformatics.

MR: To start a consulting firm that works with large companies to better improve their approach to product development using biological solutions.

DF: To be a PI in a research lab to further research on artificial organs.

If you could pick one area in BioE to do research on, what would it be and why?

SA: Tissue engineering. It incorporates a lot of what I'm passionate about, and has direct applications that could have life-altering impact.

RL: Genomic engineering or gene circuits.

JY: Probably something with neurology and prosthetics just because it seems interesting.

MR: The prosthetics or pharmaceutical aspects of BioE are probably where I would focus potential or future research.

SB: I'm very interested in the environment and sustainability, so I'd like to do research on topics regarding environmental issues, like carbon capture and sequestration or biofuels.

DF: Artificial hearts.

What class are you most looking forward to?

SA: Thermodynamics (BIOE 232)! Just to see if it's as hard as everyone says ... but fluids (BIOE 331) sounds cool too.

NC: I am looking forward to the tissue engineering class (BIOE 411).

DF: I look forward to taking Biomedical Electronics & Instrumentation (BIOE 457) or the Biomaterials class (BIOE 453).

JY: Probably my senior capstone class because we will have a lot of freedom to apply what we've learned over the years.

FRESHMAN & SENIOR INTERVIEWS

Morgan Janes and Dalton Chasser, Staff Editors, interviewed 7 freshmen: Sarah Asfari (SA), Rex Ledesma (RL), Janette Yacynych (JY), Nicole Cavett (NC), Manaahil Rao (MR), Sarah Bank (SB), and Danielle Firer (DF), whose responses are on the left, and 3 seniors: Shiri Brodsky (SB), Kenneth Ke (KK), and Kristina Dziki (KD), whose responses are on the right.

What inspired you to be a bioengineering major?

SB: When applying to colleges, I didn't really have a specific field that I wanted to pursue but I had always liked math and biology. At that point I wanted to select a specific major so I started doing some research on ways to combine those areas, and found really cool research going on in the field of bioengineering!

KK: As a freshman, I was inspired to declare my major as bioengineering through my high school microbiology and engineering science teachers. They both had backgrounds within industry and government and decided to pursue their passion in education and inspiring future scientists and engineers. I learned what it means to take the technical and soft skills that we learn at school and translate them into our dream job.

What are your plans post-college?

SB: I am going to be working at Deloitte Consulting as a federal Business Technology Analyst, starting in September. Between graduation and then, I hope to travel through a few continents.

KD: I will be working in consulting as a Business Technology Analyst at Deloitte in Rosslyn, VA for at least the next 2 years. I'll also use this time to decide if I'd like to go to either medical or graduate school in the future.

KK: My future plans consist of working in industry for a few years then returning to college for graduate school.

Are you glad you stayed on course?

KK: I couldn't imagine myself in any major other than bioengineering. Maybe culinary school.

SB: Although I did seriously consider switching majors a few times, I am happy that I stayed on course with bioengineering since I think that it is an extremely interesting and rapidly growing field that provided me with many post-grad opportunities.

KD: I'm glad that I will have time to work for a few years and take a break from school before deciding if I'd like to continue with either medical or graduate school. Since I'll be working for federal clients at Deloitte, I hope to work for healthcare-related clients, such as the NIH, FDA, or CDC.

What class did you enjoy the most?

KK: My favorite class is currently Biosensors taught by Dr. White. Every class we have the chance to really examine and critique what other engineers have contributed to the scientific literature of biosensors. A distinctive thing that separates bioengineers from other engineers within the Clark school is our proficiency at digesting scientific literature and learning how engineers and scientists communicate with each other across the world.

SB: Honestly, I have taken some incredible elective courses at UMD. Some of my favorites have been Honors Seminars called "How do Innovators think?" and "Language and the Mind," and hip hop dance classes. As for BioE courses, I really enjoyed BIOE404 with Dr. Hsieh, BIOE232 with Dr. Payne, and BIOE431 with Dr. White.

What is the most interesting tidbit of information you have learned so far from class?

SA: I really enjoyed ENES 100. It made me realize how important teamwork can be.

RL: Illumina sequencing

JY: I like learning about genetics. It's just interesting how so much information can be contained in such a small space.

NC: The most interesting thing I have learned is from BIOE121: how to run an agarose gel.

SB: I enjoyed learning about how massively parallel next generation DNA sequencing works.

DF: How bioengineering can include using proteins from one animal to help with surgical procedures.

If you could sit down with a BioE professor for an hour, what would you ask?

SA: How a physician might benefit from their BioE background, and what decisions it might influence.

RL: Thoughts on CRISPR/Cas9?

MR: One main question I'd like to ask is where they find the future of BioE going. Will it continue to expand to all aspects of our technological world or will it become more focused and integrated with special fields such as pharmacology or therapeutic manufacturing?

JY: Something about future careers. Probably how to get an internship/what are possible jobs for me.

NC: I would ask the professor what helped them decide what area of study to focus on.

SB: What was the most important experience for you in learning about what you wanted to do with your bioengineering degree?

DF: I would ask them what they use as inspiration for their ideas for research.

Are there any experiences you are excited about participating in within BioE?

SA: Capstone, Gemstone research, working with faculty in labs, etc.

RL: Departmental Honors research.

NC: I am excited about hopefully getting a job doing research because I think that will be very interesting.

MR: I am really looking forward to experiencing the Capstone classes as well as engage in the BioE honors program and possibly iGem in the near future.

JY: I am excited for Capstone.

SB: I'm excited to work on Capstone and get experience designing and working on a project I'm excited about.

DF: As a member of Gemstone I will be conducting research and I hope to be on a team that does meaningful research that will help further the medical field.

SENIORS: WHERE ARE THEY GOING?

What is one piece of information you would give to an incoming freshman BioE?

SB: Always make time for activities you enjoy! College isn't just about studying all the time, it's super important to do things that are meaningful to you (outside of class). Also - always ask for help when you need it - from strangers, friends, TAs, and/or professors. You'll find that there are a lot of resources out there. Building this kind of support system is one of the most important things I've learned in BioE.

KK: One piece of advice that I would give to freshman would be to trust in your ability to learn new things and never be too intimidated.

KD: I would have told my freshman self that even by the end of college, I wouldn't be 100% sure about what I'd want to end up doing with my career. As cheesy as it sounds, the most rewarding part of these past four years was the actual process of trying out so many different things to see what types of work excite me, whether it was working in a lab at University of Maryland School of Medicine or working on marketing projects at GE Healthcare.

What did you learn most from a professor?

SB: That the most important thing is to actually understand and apply the information being taught, not the grades. I have had several professors admit that they were awful students in their undergraduate careers, but have still come out to be successful.

KD: My Academic Advisor and BIOE331 professor, Dr. Christopher Jewell, helped me consider all the amazing opportunities there are for bioengineers, whether in research, healthcare, or consulting.

KK: The most important thing that I have learned from a Professor was from Dr. Jay in BIOE340. I distinctly remember him telling us, in his own excited yet deadpan way, that his course in modeling physiological systems was the quintessential bioengineering course in the entire curriculum; and if we aren't excited to learn the material, we were studying the wrong major.

What was your best bioengineering-related experience?

SB: Capstone has been incredible, since I feel like I can apply so much of what I've learned in the past four years to a project that my teammates and I feel invested in.

KK: My favorite experience has definitely been Capstone. This year long project has done a great job wrapping together what it truly means to tackle an engineering project. The countless informational interviews, brainstorming sessions at Looney's, and prototype designs that we have done has been the most fun that I have ever had working on a project and it really shows the importance of having a great team, an amazing mentor, and a great drive and passion for what we are working on.

KD: I worked at GE Healthcare where I was able to compete in a Business Design Challenge where I worked with a team of engineers and business majors to design a business plan for GE Healthcare for the year 2050. I enjoyed considering what I'd learned in my bioengineering classes about trends in healthcare and medical technology from a business perspective. My team made it to the final round of the competition and was able to pitch our idea for a revolutionary patient monitoring technology in a "Sharktank"-like scenario to the President & CEO of GE Healthcare.

Do you know how to use MATLAB?

SB: I wouldn't say proficient on my resume. :P
Not really, I have never felt very comfortable using MATLAB or any type of coding, but I have completed several assignments and projects using it.

KK: Yes!

KD: Sometimes, and if not, engineering has taught me how to use my resources and work with people to figure it out :)

On the Cover
by Adam Berger, Editor-in-Chief

The cover photo for this issue was taken in Dr. Scarcelli's biomedical optics lab here in the Fischell Department of bioegineering. This image depicts the light path from a high-power green laser as it travels through a maze of lenses and mirrors to be used for Brillouin Spectroscopy. Turn to page 17 to learn how undergraduate researcher Tom Mumford uses the technique in his research.

Editorial Board

The Catalyst editorial board consists of dedicated undergraduate bioengineering students ranging from sophomore to senior standing. We are dedicated to serving not only bioengineering undergraduates but also all other undergraduates in the sciences, admitted transfer students, prospective high school students, and anyone else interested in learning about undergraduate research here at Maryland!

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