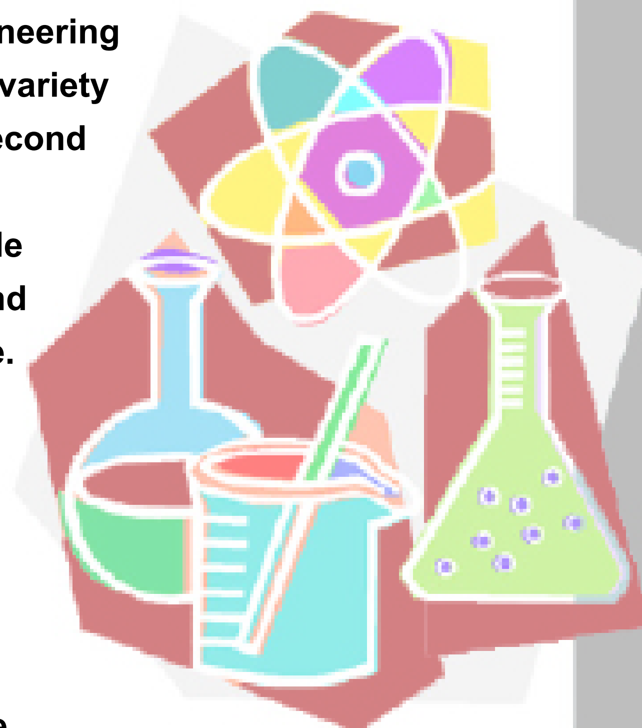

# THE CATALYST

University of Maryland's Undergraduate Bioengineering Research Journal
College Park, MD

Issue No. 1 - Summer 2014

# Want to get published in the next issue?



**The Catalyst is UMD's undergraduate bioengineering research journal. We are looking to publish a variety of related undergraduate research with our second issue coming this Fall 2014! If you are an undergraduate student working on publishable research related to biomedical engineering and biotechnology, you are qualified to participate. Contact us via email or submit your research abstract through the Google Doc link provided below.**

## No research experience?

**You can still take part in the journal's News Update sections, which showcases topics like recent advances in the field. Email us if you are intersted in contributing.**

**Submit your abstracts via the link**
**Google Doc Link (Digital version only)**

**Don't forget to like us on Facebook!**
**Facebook.com/CatalystUMD**

**For further questions contact us at:**
**thecatalystumd@gmail.com**

# Table of Contents

# Getting Involved in Undergraduate Research

Immersion into research is one of the most valuable and rewarding educational experiences during a student's time as an undergraduate. Regardless of the next step – a Ph.D., medical school, a career as an engineer in the industry, or nearly anything else – excelling in undergraduate research prepares a student for advancement in their future endeavors. This is because research places students in a unique position; a researcher must solve a problem that has not been solved before. Thus, undergraduate research requires:

- Obtaining a thorough understanding of the unsolved problem.
- Designing novel experiments to solve a problem that no one has solved before.
- Interpreting the results from an experimental approach that hasn't been attempted before.
- Identifying the importance of the results from this novel work.
- Effectively communicating the results to the researcher's supervisors.
- Reporting the results clearly and with the proper perspective to the researcher's peers.
- Seeking help from others to create a team environment when necessary.
- Acting as an independent leader to solve an unsolved problem.

Graduates who have intensely pursued undergraduate research will have obtained valuable research aptitude and experience, a solid understanding of the research methods that lead to clinical advances, creative and critical thinking skills, leadership capabilities, teamwork, and effective communication styles – all of which are coveted assets in a career in bioengineering.

*Provided by Dr. Ian White, Assistant Professor, Fischell Department of Bioengineering, University of Maryland, College Park*

# Letter From the Editor

Dear Reader,

Welcome to the first issue of *The Catalyst*: University of Maryland's Undergraduate Research Journal of Bioengineering and Biotechnology. This semester, a group of undergraduate students came together with an idea to increase student interest and involvement in research on campus. The undergraduate research here is innovative and revolutionary, and we, along with other undergraduate researchers and faculty, have come to agree that undergraduate research is fundamental to a student's academic success. This journal is meant to reveal these research experiences to current, prospective transfer, and high school students not involved in research as well as all interested in reading about the research being conducted on campus.

*The Catalyst* will be published once per semester, and is open for the submission of abstracts from any student conducting research related to bioengineering and biotechnology. Sources of student research articles can come from a research experience at faculty-run lab on campus, honors program or thesis, and/or internship. The journal's main goals are the following:

1. Galvanize interest and spur involvement in undergraduate research for students whom are not currently involved in research.
2. Create a medium for current undergraduate researchers to publish their findings.
3. Develop a more connected community of researchers and students on campus.
4. Allow undergraduate researchers to expand their research experience and influence with *The Catalyst*'s social impact section and interview sections.

This issue provides a broad range of undergraduate research from research independently conducted on the regeneration of axons in larval lamprey to the research completed by the winning senior Capstone Design team. Future issues of the journal are not limited to research in these areas, and will consider any bioengineering-related undergraduate research on campus. In future issues of *The Catalyst* there will range between four to six research articles selected by abstracts submitted through the provided links in the About the Catalyst section after the cover page.

*The Catalyst* not only showcases student-led research but also offers insightful guidance for students on starting research, contacting professors, social and ethical concerns, and past research events on campus. We want students to feel prepared for their research experience. Please read our Getting Involved in Research, News Update, and Interview sections for this information.

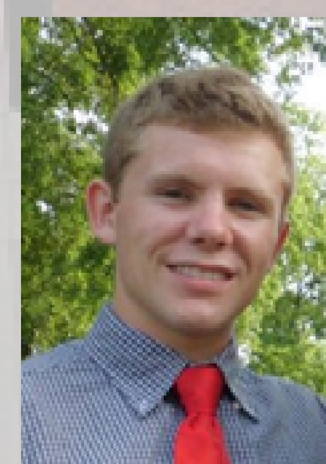
The organizers of *The Catalyst* have many people to thank for this issue's publication. We would like to thank the A. James Clark School of Engineering and Fischell Department of Bioengineering for funding our poster at the annual undergraduate research fair and being so willing to further this journal. We would also like to thank all those interviewed, by sharing your experiences you will undoubtedly help many students discover their potential on campus. Thank you to our author who went through journal review process of submission, editing, and review. The final paper is a source of inspiration for students to pursue research. Most importantly, I would personally like to thank my board, the organizers of The Catalyst, without your support and energy this journal would not have been possible.

I would also to like to thank you, the reader, for discovering this first issue out of interest to learn more about what students are researching and creating on campus related to the field of bioengineering.

You are now welcome to read *The Catalyst* – please enjoy! We look forward to future issues and of course, submissions from current engineering students to help foster the research experience for others on campus! Thank you all.

Warm Regards,

Kevin Pineault
Bioengineering, Class of 2016

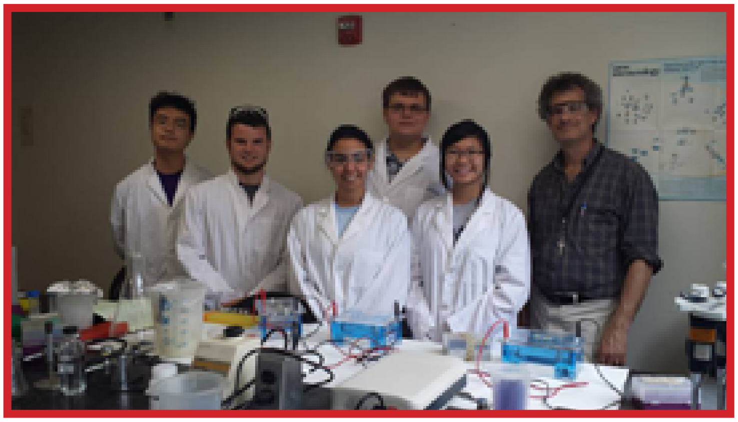


# News Update

## *Team Lamp Tries to Make the Developing World's Surgeries a Little Brighter*

Developing nations that cannot supply consistent power for their entire country are forced to shut down portions of their electrical grid, leaving many areas without power for periods of six to sixteen hours a day. Furthermore, when the grid is active, it is often unreliable and unable to provide sufficient power to meet the needs of the people. This is especially detrimental for hospitals, whose staff must resort to inadequate light sources such as crank-powered flashlights and candles in order to finish surgeries. The University of Maryland Surgical Lamp Design Team, known colloquially as Team Lamp, is composed of an interdisciplinary group of engineers and students associated with the Academy for Innovation and Entrepreneurship. Team Lamp intends to apply engineering-design skills to develop a standalone surgical lamp that functions independently of the electrical grid, ensuring quality patient care even in the case of power outages and blackouts. Outreach to developing countries will aid the design process and ultimately permit the broad distribution of the final product, alleviating the effects of power insufficiency while supporting public health.

## *iGem Competition Team Starts at Maryland*



iGem is an international synthetic biology competition, focused on creating novel innovations through genetic engineering and synthetic biology.  Our  first year team is attempting to creating a biosensor for a common oyster pathogen called Dermo. In the long term we believe this could have the potential to revive oyster populations and prevent future colony collapse. The project involves cloning, protein modification, and the chance to work with many experienced advisors. The competition offers underclassmen an opportunity to work on an advanced research project and teaches them many useful skills for future careers in industry.

## *On the Cover*

The cover image from our issue is not simply just the University of Maryland logo, but another application of bioengineering, created by the BioChip collaborative at UMD. The logo is actually a pattern of fluorescent glowing E.coli bacteria, constructed on a programmable localized hydrogel. It demonstrates the ability to use biofabrication to attach living cells in an ordered pattern to a surface. Some of the benefits of this include placing and maintaining live cells on locations within a chip where researchers "can better understand bacterial infection and antibiotic resistance, and develop new techniques for clinical diagnosis, tissue regeneration, and personalized medicine"[1].We would like to give special thanks to Dr. Gary Rubloff and his lab for allowing us to use their image and showcase their work[2].

[1] News Story. (n.d.). Bacteria Programmed to Re-Create UMD Logo. Retrieved July 6, 2014, from https://www.nanocenter.umd.edu/news/news_story.php?id=6180

[2] Cheng, Y., Tsao, C., Wu, H., Luo, X., Terrell, J. L., Betz, J., et al. (2012). Electroaddressing Functionalized Polysaccharides as Model Biofilms for Interrogating Cell Signaling. Advanced Functional Materials, 22(3), 519-528.

## *UMD-JHU Research Competition*

Undergraduates from the Clark School's Fischell Department of Bioengineering (UMD BioE) and Johns Hopkins University's Department of Biomedical Engineering (JHU BME) joined forces to host the second annual JHU-UMD Undergraduate Research Fair on March 28.

Designed to showcase the impact and quality of undergraduate research, as well as to encourage classmates to pursue their own laboratory experiences, the event was held this year at the Jeong H. Kim Engineering Building on the University of Maryland campus in College Park, MD. Guest speakers included Clark School benefactor **Dr. Robert Fischell**, Department Chair and Robert E. Fischell Distinguished Professor **William Bentley**, and Director of Mtech Baltimore, **Dr. Martha Connolly**.

"I only hope that all of you learn what I've learned over the last 40-plus years," Dr. Fischell told the audience. "Do biomedical engineering as a hobby, because it's doing well, by doing good – and there's nothing better you can do in life than say, 'I've changed the lives of 20 million people because what I did [promoted] health, and that's the most important thing for happiness.'"

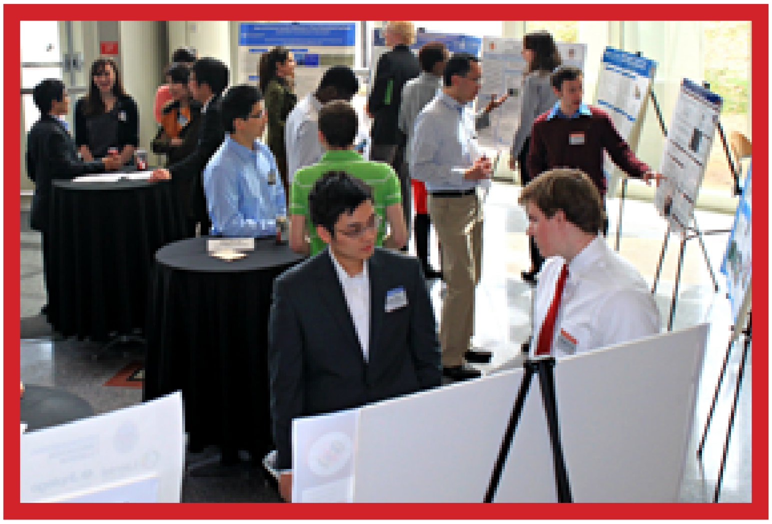
"I think biomedical engineering is a great profession," Dr. Connolly added. "Whether you're making artificial organs or scaffolds, or looking at breast cancer cell markers or some of these incredibly neat things we saw today – I can't imagine why you wouldn't just get up every day and say, 'This is the best place to be in for my career.'"
Dr. Connolly discussed the impact of biotechnology on the lives of millions and cited examples of present-day companies making a difference.

From the approximately two dozen posters exhibited, six authors were selected to deliver oral presentations. A panel of judges from a variety of outside organizations recognized the top three oral presentations, while all attendees had the opportunity to vote for the top three posters.

This year's winners were:

- **Simon Ammanuel** (JHU BME), who took 3rd Place for his poster, "24h Quantitative-EEG and In-vivo Glutamate Biosensor Detects Activity and Circadian Rhythm Dependent Biomarkers of Pathogenesis in MeCP2 KO Mice"
- **Kristen Giles** (UMD BioE), who took 2nd Place for her poster, "Competitive Displacement Reaction for DNA Sequence Biosensors Using a Stem-loop Hybridization Scheme"
- **Max Collard** (JHU BME), who took 1st Place for his poster, "Online Mapping of Task-Related Networks Using Electrocorticography"
- **Elisabeth Sooklal** (UMD BioE), who took 3rd Place for her oral presentation, "Weakly-Cytophillic Polyelectrolyte Multilayers Maintain Microtentacle Dynamics in Circulating Breast Tumor Cells"
- **Austin Jordan** (JHU BME), who took 2nd Place for his oral presentation, "Localizing Seizure Foci in Medically Refractory Epilepsy Patients"
- **Josh Temple** (JHU BME), who took 1st Place for his oral presentation, "Anatomically Shaped Vascularized Bone Grafts with Adipose-Derived Stem Cells and 3D-Printed PCL Scaffolds"

This year's event was made possible by sponsorship from the Alumni Association, BMES, Johns Hopkins University, and the University of Maryland. The organizers and attendees also wish to thank the following organizations, which provided judges for the event: Canon Life Sciences, Ingenuity Medical Device Research, Johns Hopkins University, W.L. Gore, Senseonics, BioHealth Initiative, and Mtech Baltimore.



In addition to **Luke Peterken** and **Anvesh Annadanam**, the event's organizers included UMD BMES Chapter Executive Board Members **Divya Jain**—who served as Outreach Director for the event—and **Sumouni Basu**—who served as Senior Volunteer Coordinator, as well as **Haig Pakhchanian, Winston Liu and Lily Sooklal**. Additional support was provided by UMD's **Julie Boylan, Patricia Barton, Connie Chen, Michael Burgan, Kenneth Ke, Adetola Abdulkadir, and Richard Gil II.**

## *Capstone Competition 2014*

Each year the senior class completes the two-semester Capstone in which teams investigate clinical concerns and devise solutions to address them. The program begins with a focus on problem identification and the design process, after which students develop a project proposal and subsequently design, test, and revise their projects. At the year's end groups participate in the Capstone Competition and are judged on the basis of their objectives, creativity, social impact, commercialization plan, and future potential, among other qualities. Congratulations to **Stefanie Cohen, Regina Keane, Greg Harding, Josh Nehrer,** and **Shawn Greenspan** who worked with mentor **Dr. Ron Samet** (pictured below) of UMB's Shock Trauma Center on their project "Ultrasound Pulse Monitor for Continuous Monitoring of Blood Flow during Low Perfusion States" (patent pending).

Given the approximately 500,000 instances of cardiac arrest per year in America and that the way emergency medical providers manually check for a patient's pulse is both error prone and time consuming, as a team they chose to tackle the need for improving the ability to measure pulsatile blood flow quickly and non-invasively in emergency situations. With this in mind, they designed a device to minimize the errors resulting from avoidable defibrillation by creating a tool that can provide hands-free, continuous pulse monitoring within ten seconds. Successful products require both engineering ingenuity as well as taking into consideration practical usability concerns – designing the device to be lightweight and detachable further maximizes the potential to improve cardiac arrest survival rates. While the Capstone program officially ended at the conclusion of the spring semester, among several others, this team plans on continuing prototyping and eventually bringing a product to market. We wish them the best of luck in their future endeavors.

## *Interview with Freshman BIOE*

**Angelina Nou '17**

Angelina Nou is currently a first year bioengineering major. In her spare time, she is also a member of the Gemstone Honors Program, Team Lamp, BMES, and the UMD Fencing Club.

*What made you chose to do BIOE? What specifically within bioengineering piques your interest?*
"It sounded cool. I like biology and I feel like you can do more as a bioengineering major than just a biology major. Also, I think more like an engineer than most people. I like to make things and get my hands dirty. I like the more chemical and medical aspects of bioengineering. Honestly, though, everything seems cool and I'm still trying to figure these things out."

*What has been your favorite class thus far?*
"My favorite class so far has been organic chemistry I. It is the first class where the material is extremely intensive, and it is a different way of thinking about chemistry. I think my brain just works in a way that's good for orgo."

*What class do you look forward to the most these next few years?*
"Surprise me. I honestly have no clue. I honestly don't know what I like, but that's the point right?"

*Looking into the future, where do you see yourself in ten years?*
"In ten years, I see myself doing bioengineering to help solve global poverty. I think combining bioengineering with crises and poverty in the developing world would be ideal. In general, I am sure that I will be working in a research lab."

**Diana Curtis '17**

Diana Curtis is a freshman BIOE major. In her spare time she likes to run marathons and take photos. She is also a part of the Gemstone Honors Program.

*What made you chose to do BIOE? What specifically within bioengineering piques your interest?*
"I chose to do BIOE because I found biology to be very interesting, but wanted to apply it to people. I would really enjoy doing work with prosthetics. It really interests me because I would enjoy working to make prosthetics easier for users. I once met a guy who had an older prosthetic and it made me realize how much the technology needs to improve. I also hate how the technology is not affordable to the general public."

*What has been your favorite class thus far?*
"Thus far, my favorite has been ENES100 because I had a great group to work with. My professor was also very friendly and approachable, which made the class a lot more enjoyable. The apex of the class was seeing our hovercraft work."

*What class do you look forward to the most these next few years?*
"I look forward to taking biomaterials classes in the future as they go along with my research interests."

*Looking into the future, where do you see yourself in ten years?*
"In ten years, I will either be a bioengineering patent lawyer or a physical therapist that specializes in working with people with prosthetics. I'm not sure which path I am going to follow yet."

## *Interview with Senior BIOE*

**Garrett Cavaliere '14**

Garrett Cavaliere is a recent BIOE graduate from the class of 2014. While at UMD, Garrett was a firefighter and paramedic for the Branchville Volunteer Fire Company and Rescue Squad, and an emergency medical technician for the Wayne First Aid Squad. Garrett will continue to fulfill his passion for serving the community as he pursues his life-long dream of becoming an emergency medicine physician.

*What made you chose to do BIOE? What specifically within bioengineering piques your interest?*
"I choose BIOE because I wanted to bring a critical thinking, problem solving broach to biomedical problems. Specifically I enjoy tissue engineering. I believe there are great opportunities for growth within this field, which may have a huge impact on society."

*What has been your favorite class thus far?*
"My favorite class was BIOE340, I love physiology!"

*Who has been your favorite professor so far and why?*
"Dr. White! He is very down to earth and approachable; He teaches us in a way we can easily comprehend the information and fun. Going to his lectures are engaging while also being very informative."

*Looking into the future, where do you see yourself in ten years?*
"An emergency medicine physician in a large urban hospital."

**Taylor Hearn '14**

Taylor Hearn just graduated from the BIOE major, and will be pursuing his PhD at Arizona State University. While at UMD, Taylor pursued research experiences in the Kanold Lab, at the FDA, and with the Gemstone Honors Program, while also serving frequently as a teaching assistant for Gemstone courses.

*What made you chose to do BIOE? What specifically within bioengineering piques your interest?*
"I chose BIOE because of my desire to help people while still wanting to solve complex problems. Bioengineering gave me the opportunity to explore a wide variety of subdisciplines, each of which required a different skill set. Specially, I am interested in rehabilitative technologies because of the strong focus on the patient when designing the technology."

*What has been your favorite class thus far?*
"My favorite class would have to have been Modeling Physiological Systems."

*Who has been your favorite professor so far and why?*
"Dr. White was definitely my favorite professor. He was always very down to earth and focused on giving students a practical understanding of topics, rather than making us memorize potentially useless factoids."

*Looking into the future, where do you see yourself in ten years?*
"In ten years I would like to be working as a professor in a major university. I've really enjoyed teaching class at UMD, and I'm looking forward to doing it at ASU and beyond."

**Tokunbo (TJ) Falohun**

*A senior in the Bioengineering program, Tokunbo "T.J." Falohun was raised in Nigeria but moved to Baltimore at the age of 11 where he attended middle and high school. A receipient of the Bannerker/Key scholarship, Tokunbo has been been involved in undergraduate research since his freshman year where he served as a research assistant in the Borgia lab, analyzing and coding the behavior of Bower Birds. Currently, Tokunbo works as an undergraduate researcher in the cell biophysics lab on a joint project with the (formerly called) Laboratory for Neural Control of Locomotion on characterizing nerve regeneration in larval sea lampreys. Tokunbo is also a member of the Quest Honors Program, McNair Scholars Program, University Honors Program and serves as the Vice President for the Student Community for Outreach Retention and Excellence. Outside the classroom, he enjoys photography, running and video games. After graduation, Tokunbo wishes to pursue a PhD in biomedical engineering with a concentration in Tissue Engineering.*

## ABSTRACT

The ability of the lamprey, an eel like jawless vertebrate, to achieve resolution of inflammation after spinal transection is believed to be a major contributing factor to the animals ability to regenerate its nerves after suffering from a spinal cord injury. The objective of this experimental study is to investigate how the resolution of inflammation in the larval lamprey is affected by temperature. To do this, a larval lamprey is sedated, a spinal cord transection is made, and one-micrometer fluorescent beads are injected into the region of injury in order to track the migration of the inflammatory cells in the lamprey after induced trauma to the spinal cord. Fluorescent images are then taken at different times to capture the movement of these beads. This procedure was performed on two groups of lampreys left to recover in water at different temperatures. This study brings us a step closer to understanding the capability of nerve regeneration in the lamprey after spinal cord injury. An understanding of this phenomenon could be eventually applied to human beings who currently lack the ability to repair nerves after suffering from damage to the spinal cord.

*Keywords: spinal cord injury, lamprey, nerve regeneration, resolution of inflammation*

# Dynamics of Inflammation Resolution After Spinal Cord Injury in the Larval Sea Lamprey

Tokunbo Falohun[1], Carlos Luna, Ph.D[1], Avis H. Cohen, Ph.D[2], Helim Aranda-Espinoza, Ph.D[1]
[1]Fischell Department of Bioengineering, University of Maryland, College Park, MD; [2]Department of Biology, University of Maryland, College Park, MD

## 1. Background

While not as extensively studied as other lower vertebrates such as fish and amphibians, the larval lamprey is still a widely studied model in spinal cord injury research. Due to its relatively simple anatomy, ease of imaging, simple laboratory maintenance, and most importantly, the ability to fully recover from spinal cord injury in a matter of weeks,[1] the larval lamprey is an ideal model organism.

Larval sea lampreys are able to recover from spinal cord injury through a process known as axonal regeneration. Understanding how the lamprey's axons are regenerated has proven to be challenging. While the larval lamprey's anatomy is simple when compared to that of humans, pinpointing the trigger(s) of axon regeneration is difficult because of the complexity of the nervous and immune system.

Numerous theories have been proposed, however the mechanism and conditions that promote axon regeneration in larval sea lampreys are yet to be understood. A number of studies show that an increase in the second messenger cyclic adenosine monophosphate (cAMP) increases axon regeneration however the manner in which it does so is still largely a mystery [2]. Another study explains that the absence of the inhibitor protein, myelin, could contribute to the lamprey's ability to grow new nerves [3].

In their study of spinal cord injury in mammals and non mammals, Liu et al. suggest that neurogenesis, or the ability to grow new nerves after injury, is primarily dependent on extrinsic factors that affect the permisivity of the environment [4]. Some extrinsic factors which have been identified to affect neurogenesis include (1) the presence of astroglial cells which promote regeneration by assisting axons (as evidenced in studies on non mammalian species such as Xenopus tadpoles) [5] and (2) the lack or presence of a glial scar formation after spinal cord injury.

The presence of the glial scar is believed to be the primary obstacle to nerve regeneration because it acts as a physical and physiological barrier to inflammatory cells and axon regrowth after spinal cord injury [6]. This study aims to improve the understanding of how the lamprey is able to recover from spinal cord injury by investigating the dynamics of the lamprey's immune response leading up to the formation of the glial scar.

## 2. Introduction

Serving as the primary connection between the brain and the rest of the body, the spinal cord regulates almost all physiological functions in the human body. From the detection of external temperature to the regulation autonomic activity such as respiration and heart rate, the spinal cord, which is consisted of millions of neurons, coordinates activities essential for life by relaying electrical signals between the brain and the peripheral nervous system. This collection of soft nervous tissue is enclosed and protected by the vertebral column, the "spine", which it is commonly referred to.

A severe enough blow could lead to the dislodging or fracture of a vertebra, which damages the fragile nervous tissue of the spinal cord. Injury to the spinal cord could be devastating, the severity of which depends on the location of injury. This condition is often life changing. In many cases, patients become paraplegic and are confined to a life in a wheelchair with a continuous need of physical therapy and medical care [7] which could easily cost a patient over a million dollars over a lifetime in more severe cases [8]. In the United States, about 1.2 million patients are paralyzed from a spinal cord injury [4] and the estimated annual costs of medical and rehabilitative care for spinal cord injury is 9.7 billion dollars [9]

An improved understanding of the pathophysiology of spinal cord injury has lead to numerous advancements in the treatment of the condition however current interventions primarily act to minimize the secondary effects of spinal cord injury [10]. While physicians have found some success in preventing further damage to surrounding tissue around the point of injury, very little progress has been made in the sector of neurogenesis in human patients [4].

Scientists currently look to model organisms with neurogenic ability to learn more about how the process of nerve regeneration could be replicated in human beings [11]. The sea lamprey, an eel-like jawless fish, displays these characteristics. While the mechanism behind the neurogenesis in the sea lamprey is far from understood, studies have shown that the temperature of the environment in which the lamprey is left to recover in affects this process. A study by Cohen et al. on the effect of temperature on the outcome of spinal cord regeneration in larval lampreys found that lampreys "kept at room temperature recovered full locomotor behavioral function, while a majority of those that recovered at a colder temperature exhibited dysfunctional locomotor behavior" [12]. This study takes a further look into the effect of temperature on neurogenesis.

The lamprey's ability to clear its injury site to achieve resolution of inflammation is believed to prevent the formation of the glial scar, which interferes with nerve regeneration. The objective of this study is to understand how is the larval lamprey's inflammatory response to spinal cord injury is affected by temperature. A better understanding of the lamprey's ability to achieve resolution of inflammation would likely provide some insight on how the organism is able to regenerate its nerves after injuring its spinal cord. Knowledge gained from this research could be applied to human beings and would bring us one step closer to solving the problems caused by the permanent damage of spinal cord injury.

## 3. Experimental Methods

This experiment involves two major procedures. First a spinal transection is performed on the lamprey. Secondly, to track the migration of the substances (blood clots, pathogens, e.t.c.) present in the injury site after spinal cord, fluorescent beads were injected near the point of transection in the lamprey about an hour after the transection is made on the spinal cord of the larval lamprey. Although adult and larval lampreys possess similar regenerative capabilities (Lurie & Selzer, 1991), larval lampreys were used in this experiment because of their availability and longer lifespan. Two days after the injection of the fluorescent beads, the lamprey is anesthetized for imaging with a dissection microscope with fluorescence capability.

This procedure was performed on two groups. The first group (Group 1) being 5 lampreys left to recover in water around 20°C (68°F) and the second group being 5 lampreys left to recover in water of about 10-11°C (50-52°F). Of the five lampreys that were injected with the fluorescent beads in Group 1, three of the healthiest lampreys were selected for the comparison of bead spreading because two of the five lampreys were visibly unhealthy.

## 4. Results

### 4.1. Length & Width of Fluorescent Bead Spread

After the fluorescent images of the injected lampreys were acquired, the spread of the fluorescent beads were quantified using ImageJ, an image analysis program. The pixel intensities of the fluorescent images were plotted on a two dimensional graph with the x axis representing the length in pixels and the y axis representing the summation of pixel intensities at that point in the x axis, as shown in (C) and (D) of Figure 1. Using the distribution of pixel concentration, the pixel length in which 95 percent of the beads were concentrated in was used as the width measurement of the fluorescent beads spread. This pixel measurement was then converted into micrometers using a known pixel to μm scale as show in Figure 1. To obtain a width of the bead spread, each image was simply rotated 90 degrees and measured in the same way as the width.

## 5. Protocol to Publication

The neurogenic ability of the larval lamprey makes it an invaluable model in the study of nerve regeneration. Observing this species regain locomotive function after spinal cord injury may initially seem like a miracle however, researchers are beginning to unravel the mysteries behind this phenomenon. Environmental factors such as temperature have been shown to affect axon regeneration in lampreys therefore understanding the reasons behind environmental effects may unravel some of the mysteries behind nerve regeneration.

This study takes a closer look at why exactly temperature affects neurogenesis in larval lampreys by investigating how the resolution of inflammation ensuing spinal cord injury is affected by temperature. Incidentally, the scope of this project falls under the umbrella of a larger and more comprehensive study of the neurogenic properties of the larval sea lamprey. The latter project was completed by PhD candidate (now a post-doctoral fellow) and is to be submitted to

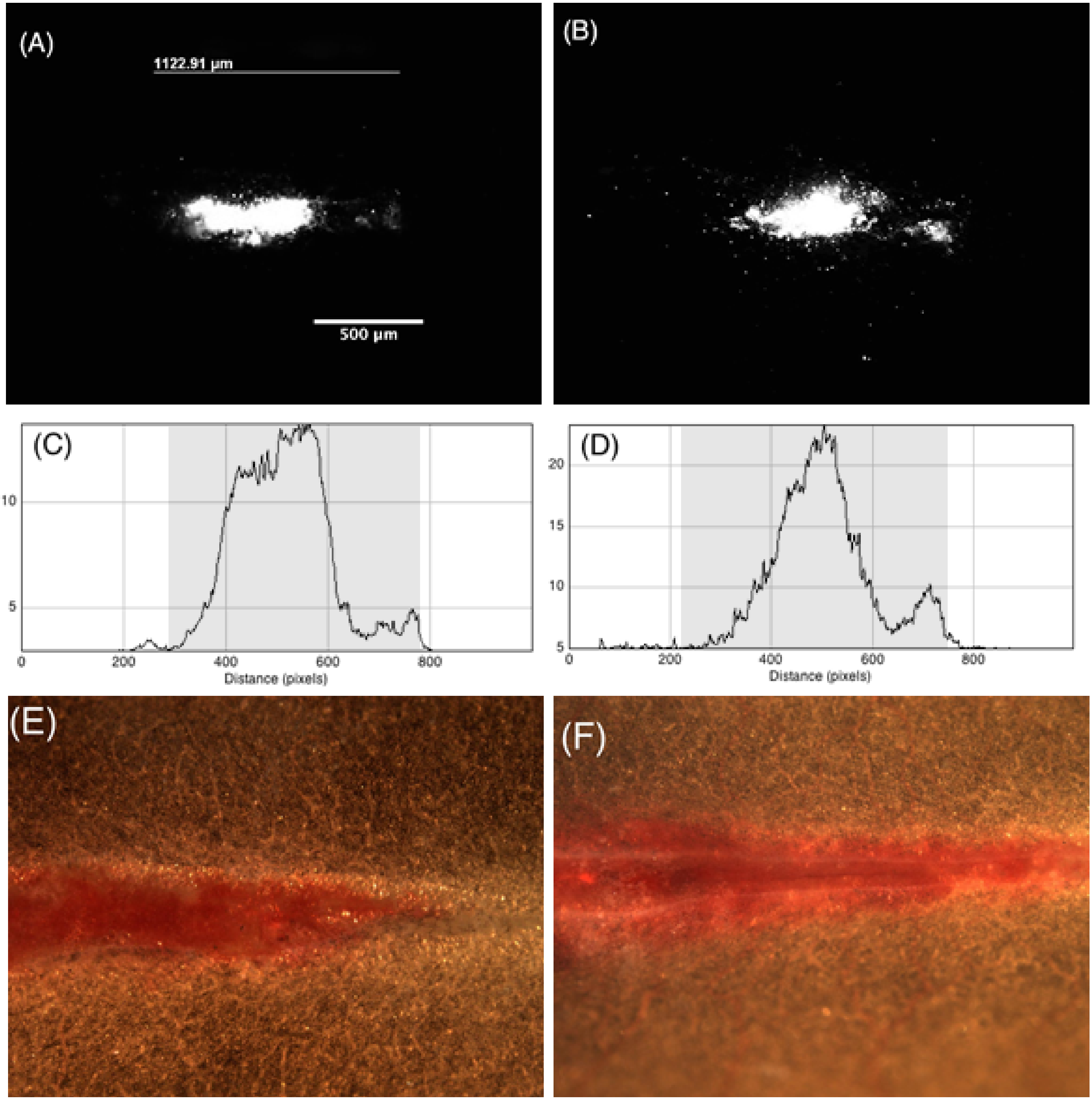



Figure 1. Fluorescent images taken 2 days (A) and 12 days (B) after spinal transection. Image (A) shows and example of the pixel to μm conversion used for statistical analysis. Image (C) and (D) display the distribution of the pixel concentrations of images (A) and (B) respectively with the lightly shaded regions being where 95 percent of the beads are concentrated. Images (E) and (F) are bright field images of images (A) and (B) i.e. the same images without fluorescence.

the Journal of Experimental Biology; as a result, the findings of this study are withheld in order to avoid any possible copyright complications that may arise.

## 6. Social Implications

Approximately two hundred and fifty thousand people in the United States live with a spinal cord related disability with the estimated annual costs of medical and rehabilitative care for spinal cord injury being 9.7 billion dollars [9]. Knowledge from this study could provide a set of conditions that would create an environment inductive to the regrowth of nerve cells in human beings which would and lead to recovery from spinal cord injury.

## 7. References

1. Pale T, Frisch EB, McClellan a D. Cyclic AMP stimulates neurite outgrowth of lamprey reticulospinal neurons without substantially altering their biophysical properties. *Neuroscience*. 2013;245:74-89. doi:10.1016/j.neuroscience.2013.04.016.

2. Lau BYB, Fogerson SM, Walsh RB, Morgan JR. Cyclic AMP promotes axon regeneration, lesion repair and neuronal survival in lampreys after spinal cord injury. *Exp Neurol.* 2013;250:31-42. doi:10.1016/j.expneurol.2013.09.004.

3. Mcclellan AD. *Animal Models of Spinal Cord Repair*. (Aldskogius H, ed.). Totowa, NJ: Humana Press; 2013. doi:10.1007/978-1-62703-197-4.

4. Lee-Liu D, Edwards-Faret G, Tapia VS, Larraín J. Spinal cord regeneration: lessons for mammals from non-mammalian vertebrates. *Genesis.* 2013;51(8):529-44. doi:10.1002/dvg.22406.

5. Lee-Liu D, Edwards-Faret G, Tapia VS, Larraín J. Spinal cord regeneration: lessons for mammals from non-mammalian vertebrates. *Genesis*. 2013;51(8):529-44. doi:10.1002/dvg.22406.

6. Sofroniew M V, Vinters H V. Astrocytes: biology and pathology. *Acta Neuropathol*. 2010;119(1):7-35. doi:10.1007/s00401-009-0619-8.

7. Sadowsky C, Volshteyn O, Schultz L, McDonald JW. Spinal cord injury. *Disabil Rehabil*. 2002;24(13):680-7. doi:10.1080/09638280110110640.

8. McKinley WO, Jackson a B, Cardenas DD, DeVivo MJ. Long-term medical complications after traumatic spinal cord injury: a regional model systems analysis. *Arch Phys Med Rehabil*. 1999;80(11):1402-10. Available at: http://www.ncbi.nlm.nih.gov/pubmed/10569434.

9. French DD, Campbell RR, Sabharwal S, Nelson AL, Palacios P a, Gavin-Dreschnack D. Health care costs for patients with chronic spinal cord injury in the Veterans Health Administration. *J Spinal Cord Med.* 2007;30(5):477-81. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2141733&tool=pmcentrez&rendertype=abstract.

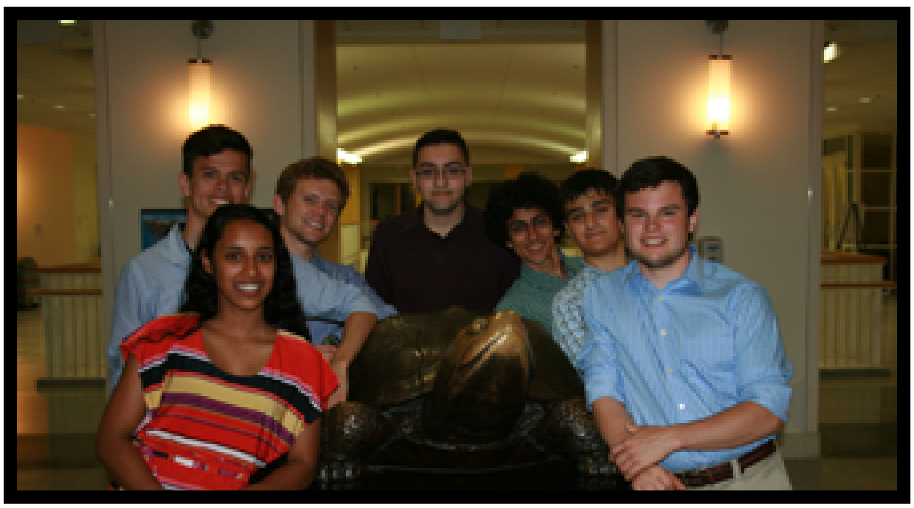
10. Sarhan F, Saif D, Saif A. An overview of traumatic spinal cord injury : part 1 . Aetiology and pathophysiology. 2013;8(6).

11. Wood MR, Cohen MJ. Synaptic regeneration and glial reactions in the transected spinal cord of the lamprey. *J Neurocytol.* 1981;10(1):57-79. Available at: http://www.ncbi.nlm.nih.gov/pubmed/7310446.

12. Cohen a. H, Kiemel T, Pate V, Blinder J, Guan L. Temperature can alter the functional outcome of spinal cord regeneration in larval lampreys. *Neuroscience.* 1999;90(3):957-965. doi:10.1016/S0306-4522(98)00502-8.

# Editorial Board

The Cataylst editorial board consists of eight dedicated undergraduate bioengineering students ranging from freshman 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!



Group photo alongside University of Maryland's mascot, Testudo.
Members from left to right: Luke Peterken, Lily Sooklal, Kevin Pineault, Nariman Ziaee, Milad Emamian, Adam Berger, Nathan Barber, Haig Pakhchanian (not pictured)

# Acknowledgements

Faculty

Research authors and Interviewed Students

Fischell Department of Bioengineering, University of Maryland