12TH ANNUAL UNDERGRADUATE RESEARCH SYMPOSIUM

AUGUST 3, 2023 | 1:30 - 3:30 PM
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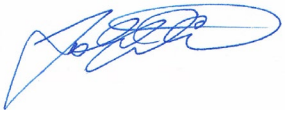
Welcome to the 2023 Undergraduate Research Symposium!

REU Students, Mentors, Home Advisors, and Friends,

It is with great pleasure and excitement that I welcome you to the 12th Annual VINSE REU Poster Session and Concluding Banquet. This year has once again been exceptional, benefiting greatly from the highly talented, hard-working, and wonderful REU students we have had the pleasure to host. Over this summer we have had some fantastic outings, social gatherings, and hopefully the students have gotten to make some lifelong friendships. The VINSE REU program has been dedicated to providing opportunities for undergraduate students to learn the skills and develop the creativity to become world-class nanoscience and engineering researchers. Based on this, we are so excited to announce that we have been approved for another three-year term!

The VINSE REU program has been on going now for 12 years, and I am deeply grateful for the opportunity to serve as Director for the next three years and hope that you will join me in helping us identify the next group of highly talented students for this opportunity! Thank you again for attending and we hope you enjoy the festivities!

All the best!



Josh Caldwell

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University of Tennessee, Knoxville
VINSE NSF-REU (Dong)

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2023 VINSE NSF-REU Fellows and VINSE Tech Crew

1 – Emily Buckner | VINSE REU

Wirelessly Actuated Soft Miniature Robots with Integrated Microfluidic Modules for Targeted Drug Delivery

Emily Buckner[1,3,5], Boyang Xiao[1,3,4], Yilan Xu[1,3,4], Xiaoguang Dong[1,2,3,4]
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The inherent softness of soft robots offers unique advantages in medical applications where safe interaction with surrounding biological tissues is crucial. Soft robots made of smart soft materials allow for programmable functionalities by spatially patterning material properties. More recently, magnetic actuation has gained significant attention due to its ability to wirelessly control soft robots for medical operations. Despite recent advances, the development of wireless soft robots for minimally invasive medical procedures that can traverse complex terrains remains challenging. In this study, we propose an untethered soft robot actuated by magnetic fields and integrated with microfluidic channels to achieve on-demand and targeted drug delivery in complex, confined environments within the body, such as the gastrointestinal (GI) tract. The robot, constructed at the millimeter scale through laser lamination and layer-by-layer assembly, boasts optimized material properties and dimensions to facilitate multi-modal locomotion and targeted drug delivery functions. By employing a tailored magnetization profile design, the robot exhibits various modes of locomotion, including crawling and climbing. Furthermore, the integration of microfluidic channels into the robot body, along with an origami-inspired self-folding pump and flexible valve, enables precise control of drug delivery. To actuate the robot's movement, we have designed a customized electromagnet array that accurately directs and regulates the magnitude of the applied magnetic field. Finally, we experimentally validate the robot's locomotion and drug delivery capabilities in phantom structures. This novel soft robot design holds great potential to navigate complex terrains and serve therapeutic functions in biomedicine as well as on-demand and targeted drug delivery, minimizing the side effects of overdosing during medical treatments.

Bio. Emily Buckner is a rising senior at the University of Tennessee, Knoxville pursuing a degree in mechanical engineering. She became involved in undergraduate research in the Advincula Lab where she works jointly between the Institute for Advanced Materials and Manufacturing and Oak Ridge National Laboratory on the additive manufacturing of nanocomposites. For this research, she has been awarded two research grants, presented at national conferences, and co-authored the paper “Digital Light Processing (DLP): 3D printing of polymer-based graphene oxide nanocomposites—Efficient antimicrobial material for biomedical devices”. In addition to research, Emily is the President of the Tau Beta Pi Tennessee Alpha chapter, an ambassador to UT’s Engineering Professional Practice Office, and involved in the Society of Women Engineers.

2 | JONATHAN GONZALEZ RODRIGUEZ | VINSE REU

Understanding the Role of Microtubules and Focal Adhesions in Breast Cancer Cell Migration

Jonathan Gonzalez[1], Jenna Mosier[2], Emily Fabiano[2] & Cynthia Reinhart-King[2]
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Cancer metastasis, an advanced stage of cancer, is responsible for 90% of cancer-related deaths. In this process, cancer cells migrate from the primary tumor to different regions in the human body to form secondary sites. Cell migration is a complex stage in this process requiring the coordination of cytoskeletal components and focal adhesions. Microtubules provide structure as well as internal organization of the cell. Vinculin, a key focal adhesion protein, connects the surrounding matrix and the cell cytoskeleton. Microtubule destabilization has previously been reported to increase focal adhesion size, resulting in increased vinculin recruitment to focal contact sites. While previous research has primarily focused on the physical link between actin and focal adhesions, or the individual roles of microtubules and focal adhesions, the interplay of vinculin and microtubule dynamics in directing cancer cell behavior is still unknown. To assess this relationship, we created a vinculin-knockout cell line using CRISPR/Cas9 and visualized microtubules using a live-cell dye. Additionally, we used nocodazole, a pharmacological agent to disrupt microtubule polymerization, to understand how migration is affected by microtubule and vinculin organization. Using 500 nM nocodazole treatment, we found that microtubule front:rear distribution was significantly decreased in control, but not vinculin-knockout cells. Control cells moderately decreased velocity, while no change was observed in vinculin-knockout cells with treatment. Future work in this project will involve using representative, 3D collagen microtracks to further elucidate the role of vinculin and microtubules in a physiologically relevant environment to potentially highlight key therapeutics for treating cancer metastasis.

Bio. Jonathan Gonzalez is a rising junior at the University of Puerto Rico Mayagüez studying mechanical engineering. Through his education journey, he had the opportunity to join the research team Innovating Design Decisions in Engineering and Applied Systems (IDDEAS) and optimized patient waiting time at a cardiologist's office. Here, he collected and analyzed samples to improve patient waiting time. Furthermore, he shadowed the creation of A3B, an emergency ventilator with the aim of being the first FDA-approved ventilator in Puerto Rico. Currently he is an REU student at the Vanderbilt Institute of Nanoscale Science and Engineering (VINSE) investigating microtubule-mediated behavior of vinculin knockout breast cancer cells in confined migration. After completing his undergraduate degree, Jonathan aspires to obtain a Ph.D. in biomedical engineering to further his contributions to healthcare.

3 | PENELOPE FRIES | VINSE Tech Crew

Electron Beam Lithography: Mixed Aperture Patterning

Penny Fries[1], Christina McGahan[2]
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[2] *Vanderbilt Institute of Nanoscale Science and Engineering, Vanderbilt University*

Electron beam lithography (EBL) is the process of using an electron beam to write a small pattern on a substrate coated with an electron beam sensitive resist. After exposure, exposed resist is washed away with a developing solution, creating a micron-scale stencil for uses such as microelectronics. Using a large aperture, the electron beam can produce a pattern quickly, but with limited pattern precision. A smaller aperture can produce a precise pattern but takes significantly more time. The purpose of this project is to use a mixture of apertures to quickly produce a precise pattern. Using the Raith eLINE EBL, an outline of the pattern can be written using a small aperture (20 microns), creating small details and sharp corners with high precision. The rest of the pattern can then be quickly filled in with a larger aperture (60 microns). This process capitalizes on the strengths of the equipment, while minimizing less desirable aperture qualities. After testing, it was found that a 60 micron aperture is not effective at creating gaps narrower than 1 micron. Using this information, a pattern was created with a 20 micron aperture outline that is 2 microns in width, and a 60 micron aperture fill, reducing the time needed to write a test electrode pattern by 30 minutes (if a 20 micron aperture were used to write the whole pattern). Based on the ratio of perimeter to area of one's pattern, the time saved with this mixed aperture method will vary.

Bio. Penny Fries is a junior majoring in Chemical Engineering and minoring in Chemistry and Environmental Engineering. She joined the VINSE Undergraduate Technical Crew in the summer of 2023. Penelope focuses on electron beam lithography process development, specifically for mixed aperture patterning. She is also trained on the laser writer and scanning electron microscope. As part of the Tech Crew, she helps with upkeep and maintenance of the cleanroom as well as troubleshooting of research tools. She has previous research experience as a research assistant in the Lin Research Group in the Department of Civil and Environmental Engineering, where she focused on nanofiltration with metal-organic frameworks (MOFs).

4 | DEBORAH OKE | VINSE REU

Rediscovering Lost Rock Art Painting Techniques

Deborah Oke[1], Blake Catlett[2], Tony Peng[2], Emma Endres[2], Janet Macdonald [2,3]
[1] *Northeastern University, Department of Chemistry & Chemical Biology, Boston, MA, 02115*
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Hundreds of years ago, the Anishinaabe people of the northern US and Southern Canada region painted on cliff sides along lakes, which leaves their art susceptible to wear and erosion – or so one would think. How to create these long lasting works of art have been lost within the culture. Previous studies have found that the main pigment is hematite, and a substance with high amounts of silicon are found below, above, and mixed within the paint layer. Using various plants native to the region and of cultural -significance, different lyes were made from the ashes of these plants to create a natural source of silica that can be painted. The silicon content of the lye was dependent on the ashing time and the identity of the plant. Chemical analysis techniques including Inductively Coupled Plasma Optical Emission Spectroscopy and X-ray Fluorescence were used to analyze the amounts of silicon in the lyes. Lyes made from sweet grass and horsetail had the highest amounts of silicon in them relative to other plants including cedar, red osier dogwood, and tamarack bark. In regards to painting, the use of water glass to represent the silicon layer beneath and above the paint aided in the overall durability. Going forward, additional plants will be used to continue making and testing lyes, as well as industrial tests to provide quantitative analysis of the durability of the paint.

Bio. Deborah Oke is a rising second year Honors student at Northeastern University, studying chemistry. She is a member of Northeastern University's Student Affiliates of the American Chemical Society, NuSci, and serves as an Honors Ambassador. During her first year, she created a curriculum surrounding molecular structure and bonding theories to be taught at a local high school, got to volunteer with the American Chemical Society for National Chemistry Week, and has aided Northeastern's Department of Chemistry by being a student interviewer for potential faculty members. She hopes to join a lab at her home institute this fall to continue expanding her research experience.

5 | MEGAN PIERCE | Chemical Biology REU

Developing an Inhibitor of XPA-RPA Interaction using a Fragment-Based Drug Discovery Approach

Megan O. Pierce[1], Areetha D'Souza[2,3], and Walter J. Chazin[2,3]
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Nucleotide excision repair (NER) is the primary DNA repair pathway used to repair bulky lesions, including those caused by UV radiation and adducts formed from platinum-based anticancer drugs. NER decreases the efficacy of platinum-based treatments by removing and repairing platinum lesions in the DNA. As a result, small molecule inhibitors of NER have the potential to sensitize tumor cells to platinum-based anticancer treatments. Xeroderma pigmentosum complementation group A (XPA) serves as an essential scaffolding protein specific to the NER pathway. A previous study has shown that the interaction between the XPA DNA binding domain (XPA DBD) and its binding partner replication protein A (RPA) is critical for effective repair of bulky DNA adducts and that mutations in its binding interface inhibits NER. Our goal is to develop a high affinity inhibitor to target the XPA-RPA interaction using a fragment-based drug discovery approach. Following this strategy, multiple small fragments are identified that bind at the XPA-RPA interface. Once identified, multiple fragments binding at different sites in the interface can be linked together to generate a specific inhibitor with a high binding affinity that is capable of disrupting the interaction. Nuclear magnetic resonance (NMR) was used to screen a ~14,000 fragment library to identify low affinity binding hits. Here, XPA DBD was expressed, purified and co-crystallized with a hit to identify the location and orientation of the fragment in the XPA-RPA interface. This hit can then be elaborated and linked in the future with other fragments to increase the overall affinity for the binding target.

Bio. Megan is a rising junior attending the University of Alabama and is majoring in chemical engineering and chemistry. She is involved in Alpha Omega Epsilon, an engineering and technical science sorority, and Gamma Sigma Epsilon, a national chemistry honor society. Outside of the lab, she enjoys playing basketball, videogames, and going outdoors. Megan plans on attending graduate school to obtain a PhD in biochemistry after obtaining her bachelor's degree.

6 | ETHAN RAY | VINSE REU

Controlling and Manipulating Confined Infrared Light in MoO_3 via Polaritonic Design

Ethan D. Ray[1], Saurabh Dixit[2], Mingze He[2], Joshua D. Caldwell[2]
[1]Department of Materials Science and Engineering, Georgia Institute of Technology, Atlanta, GA
[2]Department of Mechanical Engineering, Vanderbilt University, Nashville, TN

The Infrared (IR) spectrum of light is crucial for various applications such as thermal imaging, molecular sensing, free space communication, and many others. However, the long free-space wavelength of IR light greatly limits its applications in chip-scale devices. This problem can be circumvented using hyperbolic van der Waals materials that exhibit hyperbolic anisotropy in which the dielectric permittivities along the principal crystal directions exhibit opposite signs. Such hyperbolic materials can confine high-momentum (short wavelength) electromagnetic waves with the help of phonon polaritons — a quasi-particle made up of the hybridization of charged dipoles in a crystal and photons (an external light source). In this work, we investigate sub-wavelength wedges of a hyperbolic material known as alpha-phase molybdenum trioxide (α-MoO_3) to demonstrate in-plane tight focusing of electromagnetic waves beyond the diffraction limit. We design our wedges by optimizing geometrical dimensions using 3D numerical simulations. Thereafter we fabricate such structures through mechanical exfoliation and focused-ion beam etching. Furthermore, we investigate the effect of geometrical confinement on changing the propagation direction of phonon polaritons in the forbidden direction. In addition, we explore the image polariton effect on propagation direction and tight in-plane focusing of phonon polaritons by introducing a perfect electric conductor beneath an α-MoO_3 hyperbolic thin film. We observe that the confinement is greatly enhanced due to the image charge effect. These findings open avenues for chip-scale mid-IR nanophotonic devices and optical components with the ease of van der Waals integration.

Bio. Ethan Ray is a rising 3rd-year Materials Science and Engineering (MSE) major from Lexington Park, MD, studying at the Georgia Institute of Technology as a Stamps President's Scholar. His research at GT is centered around the growth of 2D heterostructures and films for multiferroic devices. He is fascinated by device miniaturization, optimization of fabrication methods, and exploitation of novel functional material properties. Outside of research, Ethan mentors students as an MSE Ambassador and serves as President and Dance-Coordinator of the GT Filipino Student Association. His choreography has garnered over 30 million views online, displaying Filipino culture on a worldwide stage and cementing his mission to preserve and educate about the Philippine arts. Ethan plans to continue working towards materials research, education, and mentorship by pursuing a Ph.D. in MSE and becoming a professor.

7 | LINDSEY WEISSMAN | Chemical Biology REU

Using Computational Methods to Select for Adenylation Domain Specificity

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[2]Department of Chemistry, Vanderbilt University, Nashville, TN

Nonribosomal peptides, also known as NRPs are a naturally occurring product, and are responsible for biosynthesis of the peptide scaffolds that contribute to a large number of clinically significant natural product pharmaceuticals such as penicillin, vancomycin and rapamycin. The discovery of antibiotics through the adenylation of enzyme specificity was traditionally completed via radioactive assay, kinetic measurements and high throughput analysis. Each of these traditional methods come with their own drawbacks. In response to these drawbacks, another model can be developed; computationally guided means to identify different amino acids in the protein that affects substrate specificity. Specifically, tyrosine in the Tyc A protein in a phenylalanine domain. This is completed by using a convolution neural network subset of machine learning followed by the statistical coupling analysis of protein 7YWJ(TycA variant) to select for amino acids that can be incorporated in tyrocidine during biosynthesis. This is confirmed by an adenylation domain assay. The outcomes of this experiment demonstrate the ability for adenylation domain specificity through computationally guided methods.

Bio. Lindsey Weissman is a rising senior attending Binghamton University in Binghamton, NY and is pursuing a Bachelor of Science in chemistry. She is interested in computational chemistry and began her exposure in the field in the Summer of 2022 under Dr. Jennifer Hirschi. After completing her undergraduate studies, she plans to go to graduate school for chemistry and computational chemistry.

8 | ELLA DZIALOWSKI | VINSE Tech Crew

Precision Control of Fluid Flow for Microfluidic Devices

Ella Dzialowski[1]
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Microfluidics is the study of how small amounts of liquid flow through channels that are microns in size. The use of microfluidic devices within research allows for experiments to be scaled down, providing a quick and cost-effective method of experimentation. Within the Vanderbilt Institute of Nanoscale Science and Engineering (VINSE) cleanroom, microfluidic devices are fabricated with any desired design, allowing cleanroom users to create custom devices for their research. However, the current method of testing these devices within the cleanroom involves manually using a syringe to push the liquid through the device. This is not a very consistent or precise method of fluid flow as the volume of fluid flowing through the device cannot be consistently controlled and there is no information provided about the flow rate of the fluid. Therefore, a Fluigent Flow EZ™ microfluidic fluid flow system was implemented to make this process more useful and reliable for cleanroom users. This fluid flow system will allow users to specify flow rates, mix fluids, and use software to control and monitor fluid flow within their microfluidic devices, as shown through this project.

Bio. Ella Dzialowski is a rising sophomore studying civil engineering at Vanderbilt University. She has received the Cornelius Vanderbilt Scholarship allowing her to attend the university with a full-tuition scholarship. Additionally, she was a member of the Dean's List for her first year at the university. Ella has conducted research at the University of Texas Southwestern Medical Center in Dallas, Texas where she investigated the effect of contact lens type on ocular surface biology and comfort and specifically looked at corneal epithelium thickness, lens wiper staining, and surface cell desquamation. This summer Ella started as a member of the VINSE Undergraduate Technical Crew where she plans to continue working throughout the rest of her time at Vanderbilt to improve the fabrication and testing processes of microfluidic devices within the VINSE cleanroom.

9 | CHARLOTTE WILLIAMS | Chemical Biology RU

Detection of Fragmented Tuberculosis DNA in Urine

Charlotte Williams[1], David Evans[2], Frederick Haselton[3]
[1]*Biochemical Engineering, University of Georgia*
[2,3]*Biomedical Engineering, Vanderbilt University*

Tuberculosis (TB), a leading infectious killer, is typically diagnosed using sputum samples, but children and HIV infected individuals are sometimes unable to produce these samples. Urine samples from TB infected patients are more readily obtained and contain *Mycobacterium tuberculosis* DNA fragments, but urine contains DNases which degrade and shorten these fragments, limiting their detection by standard PCR methods. These fragments could be used as a diagnostic marker if they could be modified for use in a PCR reaction. A method was tested using an RNA capture template to adapt the fragments for PCR detection. To avoid laboratory contamination with TB products, we demonstrated the technique using an RNA template for a mouse GAPDH target. To test the design, fragments that matched or did not match the GAPDH template were spiked into each sample. The RNA template was used to capture the complementary DNA fragments, with the non-complementary fragment samples serving as controls. Reverse transcriptase was used to extend the fragments along the capture template to include both primer sites. Importantly, the RNA capture template was degraded after extension to prevent false positives. In preliminary tests, at a concentration of 10^6 copies/mL of fragment, the complementary fragments had an average cycle threshold (Ct) of 29.39 cycles with a standard deviation of 0.50 (n=4) . The non-complementary fragments did not amplify in most cases, and when they did amplify, their Ct value was always greater than that of the complementary fragments. These results indicate that this promising approach could be further developed to detect as few as 1000 copies/mL in urine samples, which will help to increase the population that can be tested for TB.

Bio. Charlotte Williams is a senior at the University of Georgia, where she is majoring in Biochemical Engineering. She is participating in the National Science Foundation Chemical Biology REU at Vanderbilt University, where she is working in the Haselton Lab. At the University of Georgia, she has conducted research in the Marklein Lab on the optimization of mesenchymal stromal cell seeding parameters in 3D granular hydrogels. She is also Co-President of the UGA student chapter of the American Institute of Chemical Engineers.

10 | ANDRES MIGUEL COTTO | VINSE REU

Design and Characterization Techniques to Advance Integrated Photonics for Space Missions

Andres M. Cotto[1,4], Kellen P. Arnold[2], Christopher S. Whittington[2], Blake. M. Wallrich[3], James R. McBride[4], Sharon M. Weiss[2,4,5],

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Photonic integrated circuits are hybrid circuit designs that marry the data transmission efficiency of optical signaling with the compact, powerful data processing of electrical integrated circuits on a single chip. Integrated photonics research has led to strong commercial applications in communications, biosensing, and quantum computers. There is also a strong desire to develop integrated photonics for space missions, where the size, weight, power, and performance advantages of on-chip photonic systems can improve the capabilities of scientific equipment. In the Weiss group, we innovate photonic design and characterization methods for enhancing light-matter interactions at the nanoscale to advance on-chip photonic component performance and revolutionize space industry equipment. This summer, we compared energy redistribution between different nanoscale geometries in specially-designed periodic cavities in silicon waveguides, called photonic crystals. Using electromagnetic simulations, the photonic crystal unit cell designs can be tailored to match fabrication capabilities with design specifications. As we develop these photonic crystal designs, the Weiss group also works on commercially-viable photonic crystals, which are fabricated using deep ultraviolet lithography. We developed a polishing and etching technique that removes the coatings from commercially fabricated chips to reveal the photonic structures below the surface. This procedure is useful for imaging for publications and design feedback and will also be used in the future for space environment testing with/without encapsulation and biosensing experiments.

Bio. Andres M. Cotto is a rising junior at the University of South Florida, where he is earning his Bachelor of Science in Chemical Engineering. When not in the classroom, he works as an undergraduate researcher under Dr. Ryan Toomey, where he researched materials ellipsometry and developed an interest in learning about photonics. In addition to his work in curricula and research, Andres works as the elected Events Chair for the USF chapter of the American Institute of Chemical Engineers, and as the Operations Director for the USF chapter of Society of Hispanic Professional Engineers. Andres came to VINSE out of an interest to learn more about materials engineering, where he could gain insight into the life of research from Vanderbilt's research groups. He hopes to one day use his chemical engineering knowledge for the synthesis of materials used in cutting edge, high-efficiency electronics and clean energy solutions. The industries he is most interested in are renewable energy, solar cell technologies, and the space industry.

11 | FEVEN MEKETE DESTA | VUSRP

Enhancing Material Identification and Precise Temperature Measurements through Multispectral Thermal Imaging and Machine Learning

Feven Desta[1], James Wedgbury[1], Noah Holliger[2], Greg Walker[1]
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[2]*Vanderbilt University, Interdisciplinary Materials Science, Nashville, TN, 37235*

One of the challenges facing thermal imaging is the uncertainty in radiative properties of observed surfaces. We developed a unique technique that combines multispectral thermal imaging, filter-based observations, and advanced machine learning algorithms for improved temperature accuracy of unknown objects. Emission data are recorded at specific wavelengths using a thermal camera with three infrared bandpass filters. Convolutional neural networks are then used to analyze the temperature readings and identify various materials. The experimental results show that our approach is effective at improving material identification and enabling highly precise temperature measurements. This method has far-reaching implications, with advancements in quality control systems, non-destructive testing, environmental monitoring, and medical diagnostics. Leveraging the power of multispectral thermal imaging and machine learning, this study significantly advances material analysis and temperature measurement techniques, thereby benefiting a diverse array of applications.

Bio. Feven Desta is a rising senior at Vanderbilt university majoring in Mechanical Engineering. She is passionate about developing predictive models and optimizing systems to solve physical and material problems. This summer, she is a research assistant in Dr. Walker's Thermal Engineering lab, working on improving the functionality of infrared thermal cameras through multispectral imaging and machine learning.

12 | JANA GASKIN | Chemical Biology REU

Scaling Sweet: optimizing the synthetic pathway of bacterial glycan donor 2-acetamido-4-amino-2,4,5-trideoxy-D-galactopyranose (AAT)

Jana Gaskin[1], C. Elizabeth Adams[2], Alexander J. Hughes[2], Kerrick C. Rees[2], Johny M. Nguyen[2], and Steven D. Townsend[2]
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[2]Department of Chemistry, Vanderbilt University, Nashville, TN

In the face of ever-increasing antibiotic resistance mechanisms, unlocking new strategies to fight pathogenic infection is an urgent cause. A potential inroad lies in bacterial exopolysaccharides, which help govern host-pathogen interactions. However, our current understanding of the influence of specific structural motifs within bacterial glycans on the cellular immune system remains limited, highlighting the importance of further study. Towards this end, we aim to synthesize the minimal repeating units of bacterial exopolysaccharides in an effort to investigate these interactions. The bacterial carbohydrate AAT (2-acetamido-4-amino-2,4,6-trideoxy-D-galactopyranose) is found within the repeating structure of select bacterial exopolysaccharides; specifically, it was recently identified on the cell surface of *P. temperata*. To enable synthesis of AAT-containing bacterial glycans, we selected AAT as a synthetic target, specifically focusing on scaling and optimization, to expand knowledge of its character and role in the modulation of the cellular immune system. The synthesis of these glycan molecules will enable further studies on structure-activity relationships and potentially illuminate new methods to combat bacterial infection.

Bio. Jana Gaskin is a rising junior at Scripps College in Claremont, CA studying Chemistry. Outside of classwork, she is involved with Women and Minority Voices in STEM (WAMViS), Chem Club, the Asian American Sponsor Program (AASP) and several jobs around campus. She has presented her research on stereoselective non-coordinative silver counterions in the Wenzel Group at ACS Spring 2023 and SCCUR Fall 2022. She has been recognized as a Dean's List Student all four semesters of her undergraduate career and has been selected as a TA for classes ranging from Organic Chemistry to Ecology. In the future, she hopes to pursue a Ph.D. in Biochemistry or Chemical Biology, work to solve medicinally relevant chemical problems, and teach in an undergraduate or community college environment.

13 | SHEREENA JOHNSON | VINSE REU

Irradiated Extracellular Matrix Effects on Breast Cancer Cell Invasion

Shereena Johnson[1], Tian Zhu[2], Marjan Rafat[2,3,4]
[1]*Department of Bioengineering; Rice University, Houston, TX*
[2]*Department of Chemical and Biomolecular Engineering; Vanderbilt University, Nashville, TN*
[3]*Department of Biomedical Engineering, Vanderbilt University, Nashville, TN*
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Triple negative breast cancer (TNBC) has a significantly higher rate of locoregional recurrence after radiation therapy than other forms of breast cancer but has limited treatment options due to the lack of targetable hormone and protein receptors. Previous work has shown that recurrence is caused by increased recruitment of circulating breast cancer cells to the irradiated site. However, the change to the tumor microenvironment that leads to increased invasion is unknown. This project aims to determine whether the irradiated extracellular matrix (ECM) is responsible for increased TNBC cell invasion through the study of irradiated ECM hydrogels.

ECM hydrogels were created using mammary fat pads (MFPs) extracted from immunocompromised Nu/Nu mice. MFPs were irradiated to a dose of 20 Gy ex vivo using a cesium source, decellularized to ECM components, and formed into hydrogels through pH-controlled restructuring of the ECM environment. Murine TNBC cell invasiveness in irradiated vs. non-irradiated control ECM hydrogels was measured via colocalization of F-actin and cortactin in 4T1 cells embedded into the hydrogels for 48 hours, staining and imaging of E-cadherin and vimentin proteins, and an invasion assay.

Using fluorescence microscopy, we determined an increase in colocalization of F-actin and cortactin in 4T1 cells as well as increased invasion when embedded into irradiated ECM hydrogels. We also observed cell morphology changes toward a more invasive phenotype and increased expression of E-cadherin and vimentin proteins in irradiated ECM hydrogels. These results suggest that the isolated effect of ECM changes contribute to increased TNBC invasion after radiation therapy. Future work will focus on analyzing altered individual protein components of the ECM and interactions between immune cells and cancer cells in the irradiated microenvironment.

Bio. Shereena Johnson is a third-year undergraduate student, studying Bioengineering at Rice University in Houston, TX. She is originally from Orlando, Florida and attends Rice as a Questbridge Scholar. During her time at Rice, she contributed to research at the Tabor Lab in the Department of Bioengineering, which focuses on the study and manipulation of bacterial gene networks for use in disease diagnosis and drug delivery. Shereena is an active contributor to the engineering community at Rice through her roles as a Writing Mentor for Introductory Engineering Design Courses, the Fundraising Senator for the National Society for Black Engineers Executive Board, and through her future role as a Teaching Assistant for Fundamentals of Bioengineering.

14 | JACQUELINE ANATOT | VINSE REU

Macrophage-Targeted Polymer-Drug Conjugates for STING Pathway Activation to Improve Cancer Immunotherapy

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The cGAS-STING pathway plays a crucial role in the immune recognition and elimination of cancer cells, and STING agonists are being explored as next- generation cancer immunotherapeutics. Specifically, STING activation has the potential to reprogram tumor-associated macrophages (M2) into an anti-tumor phenotype (M1), further facilitating cancer clearance. STING agonists suffer from poor drug-like properties and off-target toxicities, which could be mitigated using drug delivery systems. Therefore, we aim to develop a tumor and macrophage-targeted, polymer-drug conjugate that enhances macrophage uptake of STING agonists. Due to the overexpression of the mannose receptor in M2-macrophages, mannose serves as a promising cell-targeting agent. Through Reversible Addition-Fragmentation Chain Transfer (RAFT) polymerization, we synthesized 100kDa poly(N,N-dimethylacrylamide-co-Azide ethylmethacrylate-co-Mannose) terpolymers with various mannose composition. The DMA backbone enables efficient drug solubilization and prolonged circulation, while the presence of AzEMA permits conjugation of DBCO-functionalized STING agonists. Murine macrophage cell lines were polarized to an M2-phenotype and utilized to investigate uptake of our polymers. As expected, mannose functionalized polymers demonstrated enhanced uptake in M2 macrophages. An ongoing biodistribution study aims to further validate enhanced macrophage uptake by measuring polymer accumulation within macrophage-rich organs. Future studies will incorporate a STING agonist onto the lead polymer platform and demonstrate its ability to repolarize macrophages and enhance antitumor immunity. This study contributes to the advancement of polymer-drug conjugates, unlocking unparalleled potential in the realm of drug delivery technology to revolutionize therapeutic outcomes.

Bio. Jacqueline Anatot is a rising senior pursuing a B.S. in Biochemistry with a minor in MSE at the University of Florida. She is currently working as an undergraduate research assistant in Dr. Brent S. Sumerlin's research group and recently released a publication in the *JACS* titled: “Degradation of Polyacrylates by One-Pot Sequential Dehydrodecarboxylation and Ozonolysis.” Jacqueline is a recipient of the prestigious CLAS Sciences Scholars program as well as the Bristol-Myers Squibb Scholars Program. She is involved in the UF Chemistry club Outreach Initiative and intends to pursue a PhD in BME, specifically focusing on mechanisms to treat and prevent disease.

15 | AODHAN WINDLER BEATTIE | Chemical Biology REU

Ikyl and Selenium SAM Analog Generation for the Methylation of Everninomicins

Aodhan Beattie[1], Asher Hollenbeak[1], Jennifer Wurm[1], Brian O. Bachmann[1]
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Everninomicin A is an antibiotic derived from soil actinomycete *Micromonospora carbonacea* that was developed and put through clinical trials with the trade name Ziracin, but was ultimately dropped during phase III. Further derivatization of the drug is desired but the difficulty of the generation of analogs through chemical synthesis means generating unnatural everninomicin analogs through biosynthetic approaches is the most feasible approach. Our goal is to use the natural promiscuity to S-adenosyl-methionine (SAM) analogs reported in many methyl transferases to generate everninomicin analogs. To generate these analogs, *AtHOL1*, a halomethyl transferase, known to methylate S-adenosyl-homocysteine (SAH) using iodomethane, and mutants have been screened for activity on a variety of alkyl halide substrates. Additionally, chemical synthesis of seleno-adenosyl-homocysteine (SeAH) was pursued to increase the reported low stability of SAM analogs.

Bio. Aodhan is a rising senior in chemical engineering at Cornell University where he has worked in Dr. Sijin Li's lab studying soybean secondary metabolism through heterologous expression of soybean enzymes in yeast. In order to gain a fresh perspective on what research on bacterial natural product biosynthesis looks like he applied to and attended the 2023 NSF Chemical Biology REU program at Vanderbilt. This summer he worked for Dr. Brian Bachmann, learning about research on natural product derived antibiotics and the actinomycetes that produce them.

16 | TAYLOR BAUGHER | VINSE REU

Inducible Gene Expression to Drive Cell Differentiation in Renal Tubule Epithelial Cells In Vitro

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The growing use of tissue and cell cultures for the development of organ replacement therapies has brought about challenges regarding the differentiation of cultured cells. Renal tubule epithelial cells are specialized to carry out vital functions in the kidney such as reabsorption and secretion. These cells express genes such as NHE3, AQP1, and N-Cadherin to aid in water and ion transport. However, *in vitro* renal tubule epithelial cells lack the transcriptional profile to fully differentiate, decreasing transport, polarization, and metabolic activity compared to their *in vivo* counterparts. This presents challenges to biomedical research as cultures are used for bio-inspired design and conceptual frameworks. Cell differentiation in intestinal epithelial cells *in vitro* is activated by a serine/threonine kinase encoded by a tumor suppressor gene, LKB1, with the help of an LKB1-specific adaptor protein, STRAD-α (*Baas et. al 2004)*. Using a cumate gene-switch system integrated into a *piggyBac* transposon, we studied how induced expression of the LKB1 and STRAD-α genes would influence renal epithelial cell differentiation *in vitro*. Gene expression analyses proved STRAD-α and LKB1-induced cells significantly expressed more proximal tubule biomarkers when compared to control renal proximal tubule epithelial cells, but this was not dependent upon transgene expression. These findings suggest a transcriptional variation between clones that could aid in isolating new cell lines with better differentiation for future biomedical research.

Bio. Taylor Baugher is a rising third-year in the B.S. Biomedical Engineering program at the Georgia Institute of Technology. In the past, Taylor has worked as a data curator for the Pathology Dynamics Lab at Georgia Tech, where she used data mining and quality control techniques to aid in the buildout of a natural language processing model for drug repurposing. Currently, Taylor serves as the secretary for Bioinformatics at GT, a club that expands the knowledge of computational biology across campus. For the upcoming year, Taylor will serve as a teaching assistant in the biomedical engineering department at Georgia Tech, guiding first-year students through the development of their skills as academics and employees. As for graduate school, she hopes to dive more into the role of bioinformatics for personalized medicine along with expanding her current knowledge of genome engineering for biomedical applications.

17 | WILLIAM FORD | VINSE Tech Crew

Characterization of plasma-assisted cleaning techniques for improved fabrication processes

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In nanofabrication, etching involves selectively removing material**.** Plasma, first implemented in semiconductor device manufacturing, is capable of catalyzing dry chemical etching, partly replacing isotropic liquid etchants. When gaseous species are injected into a plasma-containing chamber, they are chemically energized to generate reactive byproducts that interact with a substrate's surface to etch desired material(s). Though elemental silicon etching techniques are well-developed in the Vanderbilt Institute of Nanoscale Science and Engineering's (VINSE) cleanroom, oxide/nitride layer removal remains minimally investigated. Moreover, particulate waste naturally accumulates in process chambers during additive procedures, requiring specific recipes to etch deposited remnants and "clean" the chamber for future usage – many of which have proven insufficient and/or ineffective. This work addresses this bipartite issue, first fabricating oxide/nitride-containing surfaces with plasma-enhanced chemical vapor deposition (PECVD) and then etching such surfaces with "clean" recipes. Process characteristics (e.g. etch rate, chamber appearance, etc.) were recorded following each trial to enable etch recipe optimization. Evidence-based etching protocols are borne from this data, equipping users with precise, functional cleaning methods.

Bio. William "Will" Ford is a rising third-year at Vanderbilt University double-majoring in Chemistry and Medicine, Health, and Society and minoring in Mediterranean Studies. Will has been part of VINSE's Undergraduate Technical Crew since the start of summer 2023. He previously performed computational pharmacogenetic research, curating a natural language processing tool to extract psychotropic medication side effects from pediatric in-patient clinical text. This project earned him recognition as Honorable Mention for the Olivia Erhardt Memorial Award, jointly conferred by The University of Cincinnati and Cincinnati Children's Hospital Medical Center. In the cleanroom, he specializes in plasma-enhanced cleaning systems and currently aims to develop, characterize, and optimize oxide/nitride etching procedures. Will is the recipient of the full-tuition, merit-based Cornelius Vanderbilt Scholarship, the Henrietta Hickman Morgan Memorial Award for First-Year Writers, as well as the Ohio District of Kiwanis Recognition Award. He hopes to attend medical school, confident the unique lens into nanoengineering and its multi-disciplinary applications he's acquired will transform the way he views medicine.

18 | ANNA ERMOIAN | Chemical Biology REU

Exploring Alternative Metalation Approaches for Iridium-Catalyzed Borylation

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The production and refinement of oil provides simple hydrocarbon byproducts that are inexpensive and abundant. Catalytic C-H bond activation serves as an efficient method to prepare useful organoboron intermediates from otherwise unreactive hydrocarbon feedstocks. In borylation reactions, alkyl boronate esters, a useful synthetic intermediate, can be accessed and further derivatized to different functional groups. Harsh conditions and stoichiometric quantities of expensive reagents required for other methods are undesirable for industrial applications, making catalysis, or the use of catalysts, a more attractive option.

The Schley lab has focused on the borylation of sp3 C-H bonds of unactivated substrates like linear alkanes. There is expansive literature on borylation of sp2 C-H systems such as arenes, but the literature for sp3 is comparatively slim. A previous report described a novel signature ligand system with improvements from the older systems: the 2,2'-dipyridylarylmethane ligands. These ligands are hypothesized to cyclometalate with iridium via oxidative addition. We explored transmetalation as an alternative route to access cyclometalated catalyst derivatives. Using the 2,2'-dipyridylarylmethane framework, we synthesized a new aryl bromide ligand precursor to be transformed into an aryl magnesium bromide via a Grignard reaction. This ligand-Grignard may allow for a novel pathway to iridium-catalyzed borylation, expanding upon the types of precatalyst systems we can use for borylation, and resolve some of our questions about the identity of catalytic active species.

Bio. Anna Ermoian is a rising junior at Scripps College majoring in Chemistry. At her home institution, she performs biochemical analysis and natural products research as a member of Dr. Ethan Van Arnam's laboratory and will be presenting her research at ACS this fall. She is part of the leadership of her school's Chemistry Club and works as a lab teaching assistant and peer educator. After completing her undergraduate studies, Anna plans to pursue a Ph.D. in Chemistry.

19 | ERIN BURGARD | VINSE REU

Creating More Efficient Solar Cells with Vanadium Oxide Thin Films

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Conventional solar panels currently operate at a low efficiency of approximately 25%. However, Mott insulators present a promising avenue for enhancing solar energy conversion as they have shown a theoretical potential to achieve over 65% efficiency. Impaction ionization occurs in a semiconductor if the kinetic energy of the charge carrier is greater than twice the bandgap, which may then excite an additional electron-hole pair. In Mott insulators, this process occurs over one hundred times faster than a typical semiconductor (i.e. silicon), which contributes to almost doubled efficiency, and the possibility of creating multiple charge carriers per photon absorption. The Mott insulator proposed to be used in solar energy is LVO (lanthanum vanadium oxide). However, this research focuses on V2O3 because it is a strongly correlated material that is easier to work with in the preliminary investigation of the multiexciton generation process. The films were synthesized using sputtering and annealing techniques, and characterized with xray diffraction, Raman spectroscopy, scanning electron microscopy, and atomic force microscopy. Using this model Mott insulator thin film, we successfully established a reliable recipe detailing the sputtering and annealing procedures for producing quality thin V2O3 films. This investigation contributes to the advancement of solar panel technology by providing a better understanding of Mott insulator synthesis and offering a potential avenue for improving solar energy conversion efficiency by studying impact ionization in a model Mott insulator system.

Bio. Erin Burgard is an honors undergraduate senior at Arizona State University, where she majors in Environmental Engineering and minors in Spanish and Environmental Humanities. This summer, she is researching at Vanderbilt University, where she is synthesizing and characterizing Mott insulators for solar cell applications. At ASU, she researches the stress response of perovskite thin films for use in solar cells. This work was supported by her honors thesis which was defended in May 2023 and awarded the Bidstrup fellowship, Mensch prize, Jaap Sustainability scholarship, and Fulton Undergraduate Research Initiative. Erin also works with the international water treatment non-profit 33 Buckets and spent two months in the rural communities in the outskirts of Cusco, Peru conducting research surveys and assessments. Within ASU, Erin worked as a first-generation engineering student mentor for the Fulton Engineering School with the objective to increase the retention of first-generation students in engineering. She also started a small business selling hand painted cards. She will graduate in May of 2024.

20 | JACKIE MARTIN | Chemical Biology/ REU

Developing an IL-1β Electrochemical Sensor and Integrating with a Fetal Membrane on-a-chip

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Experts theorize that inflammatory responses caused by excessive cytokine activation, primarily Interleukin-1 (IL-1), lead to all cases of Preterm Premature Rupture of the Membrane (PPROM) which leads to preterm labor (PTL). Recently, there has been a focus on developing electrochemical biosensors to detect these cytokine releases in tandem with organ-on-a-chip technologies. Here, we aim to develop one such sensor to monitor cytokine concentrations in a fetal membrane on-a-chip (FMOC) that is designed to mimic the fetal membrane's ex vivo features. Known to be present within the cervix and fetal membrane at birth, Interleukin-1 Beta (IL-1B) has been directly correlated to PPROM and PTL when its bioactivity and concentrations are heightened. The sensor described here has been developed to detect IL-1B within Group B *Streptococcus* (GBS) infected cell tissues cultured in a FMOC. IL-1B standards were analyzed using a sandwich assay design to produce a calibration curve. The reproducibility of these curves was tested and statistically analyzed. The results from these trials suggest that the sensor serves as a more rapid alternative to traditional enzyme-linked immunosorbent assay (ELISA). The current design method should be optimized to further reduce the limit of detection and increase signal precision.

Bio. Jackie Martin, a rising junior at Lebanon Valley College, is a double major in ACS Chemistry and Physics with a Mathematics minor. Whilst at Lebanon Valley College, Jackie has participated as a researcher on two separate projects. She extracted chitin, now being used for the fabrication of an antimicrobial polymer for surgical gloves, from shrimp and cicada shells through grinding, demineralization, and deproteinization in 2021 with the chemistry department. Additionally, Jackie used phase selective crystallization in lead bismuth gallate glass systems with a femtosecond laser to create and analyze glass structures in 2022 with the LVC's physics department in coordination with Lehigh Valley University. Jackie has been awarded with Lebanon Valley's Freshman Achievement Award in Chemistry in 2022 and Undergraduate Award in Analytical Chemistry from the American Chemical Society, Division of Analytical Chemistry in 2023. She was also presented the Neidig Fund for Chemistry, Departmental Award, and Honors College Scholarships. After completing her undergraduate degrees, Jackie plans to pursue a Ph.D. in chemistry with a focus in drug manufacturing.

21 | LAURA WEINSTEIN | VINSE REU

Neutrophil-Mediated Transendothelial Delivery of E-selectin Liposomes for Targeting Inflammatory Sites

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Nanomedicine is an expanding field that is revolutionizing translational medicine. Among the various nanoscale carriers, liposomal nanoparticles have gained significant attention due to their ideal size for robust transport within the environment of the body. Cell-mediated drug delivery harnesses the unique capability of nanoparticles to transport therapeutic cargo to specific destinations, such as tumors or inflamed tissues. To exploit this potential, our laboratory has developed a strategy for conjugating the protein E-selectin (ES) to the lipid-PEG shell of liposomes. This approach is advantageous as white blood cells possess ES ligands on their surface, enabling effective attachment of the liposomes to these cells. Subsequently, the liposomes can hitch a ride with white blood cells to target cancer cells in circulation or reach inflammatory sites, leveraging the immune system's natural response. Our investigation has focused on neutrophils as carriers for this cell-mediated delivery method, given their role as the body's first responders to infection or injury. By utilizing the protein Interleukin-8 (IL-8) as a signaling mechanism, we have successfully guided neutrophils to specific locations. Through comprehensive experimentation using TransWell™ migration chambers and identification through confocal imaging, we have demonstrated the ability of liposomes to attach to neutrophils and facilitate their migration across endothelial-like barriers via IL-8 signaling. These findings highlight the potential of liposome-neutrophil conjugates as efficient drug-carrying nanoparticle carriers, offering rapid and targeted relief in various medical conditions.

Bio. Laura Weinstein is a Eugene du Pont Scholar in the Honors College at the University of Delaware where she is studying biomedical engineering and nanoscale materials. At her home university, Laura is an undergraduate researcher in the Day Lab, where she researches polymeric nanoparticle synthesis for biomimetic cargo delivery. She presented her first poster in 2022 at the University of Delaware Summer Scholars Symposium as a part of the Center for Biomechanical Engineering Research (CBER) REU, and gave an oral presentation on her research as a Winter Research Fellow in January 2023. During her time at UD Laura has won the 2022 Ratcliffe Eco Entrepreneurship Foundation Switch Pitch and Innovation Sprint, 2022 and 2023 National Cyber Scholarship, and in 2023 was awarded the Biomedical Engineering Distinguished Sophomore Award. This summer Laura is grateful to be a part of the Vanderbilt Institute for Nanoscale Science and Engineering (VINSE) REU at the King Lab where she is researching cell-mediated drug delivery. After her graduation from UD, Laura plans to earn a PhD in bioengineering with a focus on nanomedicine and drug delivery.

22 | ELLIE OKONAK | VINSE REU

Nanoparticle Development For siRNA Delivery To Treat Osteoarthritis (OA)

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Osteoarthritis (OA) is a degenerative joint disease that affects over 32 million US adults and currently has no cure; treatments for OA focus on alleviating symptoms and include lifestyle changes, pain-relieving medications, and joint replacements. Short interfering RNA (siRNA) has the capability to degrade protein-producing mRNA, which can be used in OA to prevent the expression of the gene that drives cartilage degradation and ultimately inhibit disease progression. However, siRNA delivery is challenging *in vivo* due to issues such as endosomal escape and kidney clearance. One alternative method of delivery is loading the siRNA into polymeric nanoparticles (si-NPs) that enable siRNA to be delivered into the cell. The purpose of this project was to optimize nanoparticle formulation using a confined impinging jets mixer (CIJ) for effective siRNA delivery.

Various formulations of si-NPs were made using a CIJ mixer with solvent and antisolvent streams. The si-NPs contain a core consisting of poly(dimethylaminoethyl methacrylate-*co*-butyl methacrylate) (DB) to enable endosomal escape and poly(lactide-*co*-glycolide) (PLGA) for nanoparticle stability. DSPE-PEG (lipid-PEG) was used as a surfactant for biocompatibility and to prevent si-NP aggregation. The ratio of DB to PLGA in the si-NP core was varied, as well as the ratio of amines to phosphates (N:P), in order to optimize the gene silencing activity and toxicity of the si-NPs. The si-NPs were analyzed for size, zeta potential, and siRNA delivery capability. The formulation concentrations of 3 mg/mL of DB and PLGA in the solvent stream and 1 mg/mL lipid-PEG in the antisolvent stream were found to be the most successful for nanoparticle formation using the CIJ mixer. Studies investigating the gene silencing activity of the different si-NP formulations are ongoing.

Bio. Ellie is a rising third year biomedical engineering major at Bucknell University in Lewisburg, PA. She works as a study group facilitator for Chemistry and Calculus II students on-campus, and has been a teaching assistant for various calculus classes since her freshman year. Ellie also leads tours as an ambassador for the Office of Admissions, and has served on the Biomedical Engineering Society executive board. Ellie's involvement in a sophomore year cell culturing class sparked her interest in drug delivery research, which further led her to Professor Duvall's Advanced Therapeutics Laboratory through the VINSE REU. Ellie plans to pursue her PhD in biomedical engineering, and is grateful for the knowledge and support she gained this summer.

23 | KATHY ROSSY COLIN | Chemical Biology REU

Site Selective Sugar Functionalization via Pradimicin Based Catalyst

Kathy Colin[1], Valentina Guidi[2], Daria Kim[2]
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[2] *Valentina Guidi: Department of Chemistry, Vanderbilt University*
[2] *Daria Kim: Department of Chemistry, Vanderbilt University*

Pradimicin A (PRM-A) is a natural product with lectin-like function, known for its antibiotic and antifungal properties. Recent studies have highlighted its potential as a novel therapeutic agent against the human immunodeficiency virus (HIV). This is attributed to PRM-A's ability to selectively bind D-mannose, a crucial component of the innate immune system involved in host-virus interactions, via a non-covalent network comprised of Ca^{2+}-mediated chelation and hydrogen bonding. Our research aims to explore carbohydrate-ligand interactions by designing a catalyst template inspired by PRM-A. The high selectivity and binding affinity of PRM-A to D-mannose could be exploited to instigate site-selective carbohydrate modifications, which traditionally have been difficult to achieve without the use of protecting groups. Our catalyst design leverages PRM-A's non-covalent molecular recognition network while also maintaining a photo excitable motif that enables carbohydrate activation via photochemically-induced H-atom transfer events. Optimization of our catalyst includes tuning its photophysical properties by derivatizing its photoexcitable moiety. While our initial catalyst design incorporated the anthraquinone motif featured in the natural product, we are currently exploring alternative motifs such as xanthone, thioxanthone, and benzophenone, all of which are common organic photocatalysts. Ultimately, we aim to achieve site-selective carbohydrate modifications through our catalyst's non covalent network and better understand biologically-relevant carbohydrate-ligand recognition events.

Bio. Kathy Colin, a rising senior at the University of Richmond, VA, is pursuing a Bachelor's of Science in Chemistry. This summer, she had the opportunity to work in Dr. Daria Kim's research laboratory, where she was mentored by second-year graduate student Valentina Guidi. Prior to interning at Vanderbilt, Kathy gained research experience as a Neglected Tropical Disease (NTD) Research Intern at AbbVie Pharmaceutical Inc. in North Chicago, IL. During this internship, she collaborated with medicinal chemists on designing and synthesizing new small molecule inhibitors targeting Tuberculosis. Kathy's primary research interests lie in the field of synthetic organic chemistry and medicinal chemistry, with a specific focus on drug development and discovery. Her plans for the future involve attending graduate school in the upcoming year and pursuing a career in the pharmaceutical industry as a medicinal chemist.

24 | ELIAM CHANG | VINSE Tech Crew

Identifying Optimal Deposition Processes by Application for Thin-Film Materials

Eliam Huai-Yang Chang[1]
[1]*Department of Biomedical Engineering, Vanderbilt University*

Deposition is a process of adding nanoscale layers onto a substrate. Depositing a precise thickness with low-roughness film has critical implications for device functionality and how devices are utilized in research. In this work, silicon substrates were washed and fixed to a sample holder with polyimide tape in preparation for a deposition. After the deposition, stylus profilometry and atomic force microscopy were used to determine the material thickness and surface roughness, respectively. This method of deposition and characterization was applied to two problems in the Vanderbilt Institute of Nanoscale Science and Engineering cleanroom—calibrating a deposition recipe adapted from a different chamber and identifying which deposition tool will produce a thin film with the desired material properties based on the user's application of the film. Aluminum films deposited with the existing recipe on the Angstrom Amod Multimode Chamber were thinner than predicted by the thickness sensor inside the chamber. The tooling factor, which accounts for the fact that the sample and sensors are at different distances from the source and thus have different thickness, were calibrated six times after each deposition. The Angstrom Amod Multimode Chamber now deposits aluminum films whose thickness matches what the thickness sensor measures. Within the cleanroom, the Angstrom Amod Multimode Chamber and AJA ATC-2200 Sputter Chamber have some overlap in which materials they can deposit. Two such materials, aluminum oxide and chromium, were deposited using both tools and the resulting films were characterized and compared for differences in deposition rate and surface roughness, allowing users to choose the film properties of importance.

Bio. Eliam Huai-Yang Chang is a rising sophomore Crescere Aude Merit Scholar at Vanderbilt University studying Biomedical Engineering. In his freshman year, he conducted research in the Bellan Lab growing and imaging cells within microfluidic channels to understand how human arteries spontaneously expand and contract as a result of liquid (blood flow). This sparked an interest in nanotechnology for medical applications and patient care, leading to him joining the VINSE Undergraduate Technical Crew in the summer of 2023. In the cleanroom, Eliam specializes in thin-film deposition tools and characterizing techniques such as profilometry and atomic force microscopy to analyze deposition properties.

25 | RAKEL ANG | Chemical Biology REU

Synthesis and Application of Amidine Amide (AmA) Catalyst

Rakel Ang[1], Zihang Deng[2], Jeffrey N. Johnston[3]
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[2]*Zihang Deng: Department of Chemistry and Institute of Chemical Biology, Vanderbilt University*
[3]*Jeffrey N. Johnston: Department of Chemistry and Institute of Chemical Biology, Vanderbilt University*

Nitroalkanes have been extensively recognized as pivotal intermediates within organic chemistry. Their intrinsic reactivity affords a potential to transform them into an array of functional groups, such as amides, amines, and aldehydes, through a singular step. These functional groups frequently appear in drugs and other bioactive molecules, therefore cementing their importance in drug discovery and total synthesis processes. We have synthesized and utilized an organocatalyst termed AmA to enable the enantioselective reduction of nitroalkenes into nitroalkanes. Subsequently, we applied this to a specified target molecule known as (+)-SJ733. This molecule holds therapeutic promise in the treatment of malaria by inhibiting the ATPase activity of P. falciparum, a unicellular protozoan parasite responsible for the disease. Notably, no enantioselective pathway has been identified to date for the synthesis of this drug. Employing the AmA catalyst paves the way for accessing the stereocenter next to the pyridine ring. As an initial step toward the target, we applied this methodology to a model substrate. The results gleaned from this process have yielded significant insights into a critical nitroalkene intermediate, thereby underlining the practical potential of our study.

Bio. Rakel was born and raised in Southern California. She is double majoring in biology and chemistry at Pepperdine University, where she has been conducting cell biology research. After graduating in 2025, she hopes to pursue a PhD in chemical biology or medicinal chemistry. Outside of the lab, she enjoys cooking, baking, painting her nails, and playing board games.

26 | ANYA KENNEDY FRAZER | VINSE REU

Thermal Conductivity Across Metal/Metal Oxide Interfaces

Anya Frazer[1], Bradly Baer[2], Greg Walker[3]
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[3]*Department of Mechanical Engineering, Vanderbilt University*

Catalytic cracking of ethane to ethylene uses a large amount of heat energy, much of which goes to waste. The National Renewable Energy Laboratory has proposed a new method to reduce heat waste, which involves inductively heating the reaction through a layered metal/metal oxide device. We demonstrate a computational method for predicting thermal conductivity across nonequilibrium metal/metal oxide systems using molecular dynamics (MD) with a two-temperature model (TTM). The TTM allows for thermal conductivity to be modeled as a combination of lattice and electronic contributions by governing the exchange of energy between the lattice and an electronic subsystem. Iron and iron oxide were chosen as the model materials to demonstrate our method.

Our method predicts the thermal conductivities of bulk iron and iron oxide to the same order of magnitude as experiment. The addition of the TTM improved the prediction of thermal conductivity of iron compared to MD alone, indicating that electronic contributions are significant in the thermal conductivity of iron. Our system predicted a large temperature drop across the metal/metal oxide interface. The TTM created a more physical representation of heat traveling through iron, but was not applicable to the iron oxide due to a deficiency of conduction electrons. Our approach is transferrable to other metal/insulator systems.

Bio. Anya Frazer is a rising sophomore at UNC Chapel Hill, double majoring in physics and music. Prior research experience includes a senior capstone studying the impact of practice habits on harmonic content of middle and high school flute players' tone, as well as participation in a large-scale literature review through NASA's Backyard Worlds research group to catalogue known qualities of star systems within 20 parsecs. She has made the Dean's List during both of her semesters at UNC. Anya hopes to get a diverse range of research experiences in her undergraduate career to prepare her for pursuing a PhD in physics. When she is not studying physics, you can find her playing the flute in UNC's Wind Ensemble and in solo performances.

27 | ALYSHA JOHNSON | Chemical Biology REU

Standardizing Sample Preparation to Analyze Postmortem Brain Tissue in Alzheimer's Disease

Alysha Johnson[1], Angel Bodrick[2], Natalia Bastida Gutíerrez[3], Jasmin Tindal[3], Renã A.S Robinson[3]

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Alzheimer's disease (AD) is the most common form of dementia and one in three seniors (65+) dies from AD in the United States. AD disproportionately affects the African American community, however, African American adults are greatly underrepresented in basic science research. Our laboratory aims to understand molecular changes in AD in African American adults using proteomics analysis. To accommodate routine and robust analysis of large numbers of postmortem brain tissue, standardized protocols are necessary. Post-mortem Posterior cingulate gyrus (PCG) tissues (N=70) from African American/Black adults who were either cognitively normal or had AD were prepared. Samples were randomized, blended, and grouped into five batches to prepare for tandem mass tag batching. This presentation will focus on the sample preparation steps and quality control measures taken to ensure robust samples are available for proteomics analysis. This includes the assessment of protein integrity from homogenization steps.

Bio. Alysha Johnson is a rising second-year at the University of Virginia, double majoring in Chemistry and Spanish, and she is from Suffolk, Virginia. She is a graduate of the Project Lead the Way Biomedical Sciences Program where she completed college-level research in high school and a capstone which was featured to her school board. Alysha is a very accomplished student being an American Chemical Society Scholar, recipient of the Advancing Science Grant for the National Organization for Professional Advanced Black Chemical Engineers and Chemists. At her home institution she is a member of ACS, Student Council and BSA where in all of those she works to improve diversity efforts in science and her school. In her free time she enjoys traveling, language learning, dancing, and reading. She hopes to one day work in biotech or pharmacokinetics.

28 | RAEY HUNDE | VINSE REU

Stimulating Collateral Arterial Growth Using Acellular, Growth-Factor Free Hydrogels for the Treatment of Critical Limb Ischemia

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Critical Limb Ischemia (CLI) is a condition that affects millions of people all over the world who may suffer from diabetes or are chronic smokers. It is a severe blockage in the arteries caused by a buildup of plaque that significantly reduces blood flow to lower extremities like the legs. The lack of blood flow causes the surrounding tissue to become necrotic, thus requiring amputation. As of now, CLI lacks a lot of robust treatment options. In the past, clinical trials have attempted to stimulate arterial growth using growth-factor encapsulated hydrogels. Unfortunately, these clinical trials have failed to appreciably improve patient outcomes. We propose an alternative method that uses acellular-growth factor-free hydrogels to stimulate arteriogenesis. This methodology is twofold: (1) to further develop and characterize a previously studied GelCad hydrogel (gelatin-based hydrogel with Cadherin peptides attached) and synthesize this GelCad hydrogel into microspheres, and (2) to implement a cell-responsive siRNA release strategy that will trigger arteriogenesis through macrophage polarization. Preliminary results suggest GelCad microspheres can be synthesized using both a 4-Arm PEG SG (negative control) and 3,3′-Dithiodipropionic acid di(N-hydroxysuccinimide ester) (positive control) crosslinkers. 3,3′-Dithiodipropionic acid di(N-hydroxysuccinimide ester) is a reactive oxygen species or ROS active and is capable of macrophage polarization.

Bio. Raey Hunde is a rising senior chemical engineering student at the University of Maryland, Baltimore County. She has researched biomedical and chemical engineering at the following institutions: FDA: CBER, Laboratory of Virology, University of Minnesota: Twin Cities, University of Maryland, Baltimore County, Purdue University, and Vanderbilt University. Raey is a Meyerhoff and U-RISE scholar at the University of Maryland, Baltimore County, and aspires to obtain her Ph.D. in chemical engineering after graduation.

29 | DELYAR KHOSROABADI | Chemical Biology REU

Mapping Coronavirus Nonstructural Protein 2 Regions Involved in Strain-Specific Interactions

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Human coronaviruses pose a significant global health threat due to their recurring emergence. SARS-CoV-1 was the coronavirus strain involved in the 2002 outbreak, while SARS-Cov-2 is the causative agent of the COVID-19 pandemic. While extensive research has been conducted to better understand this family of viruses, there is significant variability in disease pathogenesis between SARS-CoV-1 and SARS-CoV-2 that is not well understood despite their high sequence similarity. Characterizing strain-specific host-virus protein-protein interactions will elucidate how changes in host factors may contribute to differences in the pathogenesis of SARS-CoV-1 and SARS-CoV-2. Human coronaviruses are positive-sense single-stranded RNA viruses. Upon cellular entry, the parts of the viral genome are translated into polyproteins that undergo proteolytic cleavage by viral proteases, resulting in the generation of 16 nonstructural proteins. Our research focuses on nonstructural protein 2 (nsp2). Previous work in the lab identified strain-specific interactors of SARS-CoV-1, examples of which include TMEM43, FLOT2, CLCN7, and OSTM1. Furthermore, strain-specific interactors for SARS-CoV-2 were also identified, with examples including PLD3, KIN, MAZ, and FOXK1. To better understand what regions of nsp2 contribute to these unique interactions, we create chimeras between SARS-CoV-1 and SARS-CoV-2 nsp2. Western blot and tandem mass spectrometry were then utilized to determine which sequence region of nsp2 mediates the strain-specific interactions. Characterizing strain-specific nsp2 interactors provides valuable insight into how coronaviruses manipulate cellular processes and may identify potential avenues for the development of host-directed antiviral treatments.

Bio. My name is Delyar Khosroabadi. I grew up in Iran and moved to the United States at the age of 13. I am currently a rising senior majoring in biochemistry at California State University, Channel Islands, where I am part of two research groups. In the laboratory of Dr. Gareth Harris, I investigate the underlying mechanism and novel targets of serotonin using Caenorhabditis elegans as model organisms. I am also part of the laboratory of Dr. Ahmed Awad, where I synthesize and computationally analyze novel nucleoside analogs as potential pancreatic cancer chemotherapeutics. In addition to my research involvement, I have taken on the role of an embedded peer educator for courses like general chemistry and biological statistics. I also hold leadership positions in various clubs on campus. In my free time, I like to read.

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