FALL 2024

HensonNews

Produced by Salisbury University's Henson School of Science and Technology

Henson Faculty SPOTLIGHTS

In this issue of *Henson News*, several of our faculty share their latest research. Enjoy these in-depth glimpses into amazing work being done at Salisbury University.

From the Henson Dean's Office

Greetings from the Henson School of Science and Technology! It is another beautiful (if abnormally dry) fall on the Salisbury University campus as we welcomed about 950 new and returning STEM students back to campus. But while our focus at the start of a semester is appropriately on both new and returning students, it is the faculty of our school that are its heart. The faculty provide the intellectual center of our enterprise, ensuring that our students are learning the foundational knowledge of their academic disciplines as well as providing an example of the dedication and curiosity it takes to succeed in a challenging academic field.

Nowhere are these characteristics better expressed than in the enthusiasm, intelligence and creativity of our new faculty. These professors have joined SU recently and have already made their mark on the level of achievement in our students. Because they have recently finished their doctoral degree programs or have come to us after completing a rigorous post-doctoral research experience, each have brought a new research focus, a new energy and new ways of connecting with students in the classroom. We are privileged to have them choose to build their career in the Henson School of Science and Technology and look forward to their contributions for many years to come.

I hope you enjoy learning about their research pursuits from this newsletter. If you'd like to learn more, including how to help support getting undergraduate students engaged in this groundbreaking work, please reach out at 410-543-6489 or HensonSchool@salisbury.edu.

– Dr. Michael Scott, Dean

The Weather-Pain Connection

Christopher J. Elcik, Geography & Geosciences

It has been well documented that weather affects different aspects of human health, including pain, allergies and illness. While traditional univariate and multivariate approaches have been used to determine the precise impact, unclear relationships and, in some cases, contradictory results are often reported. A potential explanation for this is that humans, as well as other elements of the biosphere, do not necessarily react to individual weather variables, rather they respond to multiple variables acting synergistically.

Based on this, I utilize synoptic classifications, which better represent the aggregate of meteorological conditions, to better understand weather-health relationships. My current work investigates the link between daily weather type and the occurrence of severe pain (e.g., migraine, fibromyalgia, rheumatoid arthritis, osteoarthritis and general back pain). In this case, severe pain is defined as requiring a visit to the hospital. Initial findings suggest that moist tropical weather types result in the greatest instances of severe pain, while moist polar weather types are associated with the fewest. Interestingly, the pressure changes associated with transitional weather types (i.e., frontal passages), do not appear to be linked to pain frequency.

In some cases, these results can be explained physiologically. During warm and muggy days, the body's response is to vasodilate, which could increase pressure throughout the body and trigger pain. It is also possible that these findings could be more behavioral. The conditions associated with moist tropical days may result in people being more likely to engage in outdoor activities that are considered strenuous (e.g., golf), thus triggering pain. Ultimately, the goal of this work is to better understand these relationships so that weather-based human health forecasts can be developed. The hope is that these new forecasts can improve the quality of life of those who use them.

A Summer of Chemistry Research and A Wonderful Mission Trip

Zulma Jimenez, Chemistry

My past summer began with a simple but exciting task: transforming an empty space into a functional chemistry lab where my ideas would take shape. The lab started to come alive as glassware, chemicals and basic equipment arrived. It was fun to shop! With the lab fairly set up, the next step was just as thrilling – designing experiments! I began to outline a series of experiments, tailoring them to the research my first student, Mahrukh Rizwan (biology major/ chemistry minor), would undertake. Together, we discussed relevant articles, defined research goals, reviewed methodologies, and talked about how her work would contribute to both my overall research and to science.

Since one of the main focuses of my research is synthetic hydrogels, I guided Mahrukh through the intricate process of hydrogel preparation, providing her with hands-on experience that became a crucial step toward building her confidence and lab independence. In this first project at SU, we explored how the length of the crosslinker affects the swelling dynamics of the hydrogels.

Based on our initial findings, the research continues to focus on investigating new monomer-crosslinker systems to better understand and optimize the properties of these hydrogels for potential applications in drug delivery. The next phase of experiments is set to push the boundaries of what we currently know. The future is bright, and thankfully, the hydrogels are transparent enough to see it clearly!

This summer was not only marked by progress in the lab, but also by meaningful experiences outside of it. I had the privilege of participating on a Christian mission trip to Quito, Ecuador, where I was able to step away from the scientific world and engage with communities in need. The mission trip offered a chance to serve others, work on projects unrelated to my research and gain a fresh perspective on the impact of service. Balancing lab work with this humanitarian experience gave me a renewed sense of purpose, highlighting the importance of using both science and service to make a difference.

Viewing Works of Art Through the Lens of Chemistry

Jessica Heimann, Chemistry

While I had always been interested in chemistry, it was not until the final year of my undergraduate studies that I found my true scientific passion at the intersection of chemistry and art. On the first day of class in a Chemistry of Art course, the professor asked us “Why is a ruby red?” and I was captivated. Analyzing the color of a ruby from the perspective of inorganic chemistry showed me that we can use the concepts and techniques we learn about in science classes to better understand materials used in artworks. Now, as an assistant professor at SU, the application of chemical tools and instrumentation to the study of materials commonly used in works of art is central to my research.

More specifically, research in my lab uses a combined experimental and computational approach to understand the chemical mixtures and spectroscopic properties of materials relevant to art and art conservation. In one current project, students are exploring a class of pigments known as lake pigments. From the eyes of an artist, a lake pigment is an insoluble, translucent pigment prepared by precipitating an organic dye with a metallic salt. From the eyes of an inorganic chemist, a lake pigment is a coordination compound in which a metal ion forms coordinate bonds with the hydroxyl and/or carbonyl groups on a dye molecule. By systematically modifying specific variables during the preparation of a lake pigment (such as the pH during dye extraction or the identity of the metal ion used), we are able to analyze how those variables impact the spectroscopic properties and color of the resulting lake pigment. Students in my lab not only gain hands-on experience using advanced synthetic methods, characterization techniques, and high-performance computing, but also delve into the history books to learn the traditional methods of pigment and paint preparation.

Nonsymmetric Macdonald Polynomials

Benjamin Goodberry, Mathematics

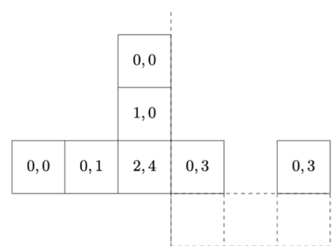
The first time we learn about ‘polynomials,’ we work with objects that look like $2x + 3$, or maybe $5x^7 - 8x^3 - 6$. As we continue on to multivariable calculus, we run into a different type of ‘polynomial,’ one with multiple variables, such as $-3xy + 2yz^2$. We can also play with what coefficients are allowed, like in $\pi x^5 - \sqrt{2}y^5$, whose coefficients are real numbers that are not integers.

In different applications, we use a variety of assumptions on what our polynomials should look like. Should we allow only integer coefficients, or any real number? Should they be only positive? In the case of what are known as nonsymmetric Macdonald polynomials, the coefficients are even more exotic rational functions in two special letters, q and t. Such a polynomial might look like

$$\left(\frac{1-qt}{1-qt^2}\right) x_1x_2 + \left(\frac{1-q}{1-t}\right) x_1{}^2$$

where the variables are x^1 and x^2. This still has the shape of a polynomial- some powers of the variables, added and multiplied, with some coefficients- but somehow contains more information than our usual-looking polynomials.

My work centers around some special combinatorial (counting) properties that these polynomials exhibit. For instance, it turns out if we want to find something to multiply one of these nonsymmetric Macdonald polynomial by to force its coefficients to not be fractions, we can look at some box diagrams that look like this:



We fill each box with two numbers, which are found by counting certain neighboring boxes to the left, to the right, and above the given box (see if you can find how those numbers are chosen!). Those become the powers of q and t we multiply by to clear out the fractions.

These nonsymmetric Macdonald polynomials are special in that by setting q and t to 0 or ∞, they transform into other types of polynomials used in both math and physics. They’re also fascinating in their own right, and my work has focused on their formulas and connections to problems in geometry.

The Bacterial Fight Club

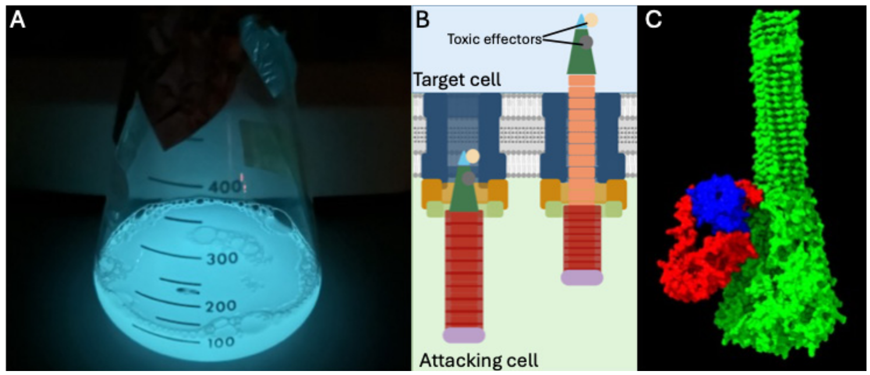
Kirsten Guckes, Biological Sciences

All animals require intimate, long-lasting relationships with microorganisms for proper development and health. The bacterial members of these relationships are called symbionts, and they also benefit from these interactions by acquiring nutrients and shelter from their animal hosts.

These host-derived benefits drive bacterial symbionts to compete with one another to establish symbiosis with a host. Bacteria have therefore evolved molecular weaponry to engage in dueling during host colonization.

One such weapon, called the type VI secretion system (T6SS), acts as a lancet decorated with toxic effector proteins that are delivered to adjacent competitor cells during these battles. Students in the Guckes lab investigate various T6SS toxins that promote interbacterial killing by determining 1) their effect on cell physiology; 2) how they are neutralized during friendly fire; and 3) how they interact with structural components of the secretion system for delivery. The lab studies a beneficial bacterium called *Vibrio fischeri* that produces bioluminescence, which its bobtail squid host uses as camouflage. *V. fischeri* uses a T6SS to eliminate competitors while colonizing the squid. It is also easy to grow and genetically manipulate, making it an excellent organism to study these complex nanomachines and their toxins.

Students in the lab have been able to generate informed hypotheses for their research projects by analyzing readily available protein sequences for their toxin of interest using an AI platform called AlphaFold3. This program, developed by Google DeepMind, can quickly and accurately model protein-protein interactions. Students have used this program to predict the structural contacts that are necessary for loading toxins onto the T6SS for delivery. Currently, students in the Guckes lab are working on mutating these toxins at these protein-protein interfaces to test these models. These projects will provide insight into the factors that impact which symbionts win this bacterial fight club and are able to establish these important symbiotic relationships.



Bacteria use the T6SS to duel during symbiosis establishment.

A) Bacteria producing their symbiotic trait, bioluminescence. B) Illustration of the T6SS adapted from Guckes & Miyashiro, 2022. Structural proteins span bacterial membranes to fire a toxin decorated lancet into an adjacent target cell. C) Model generated in AlphaFold3 showing a *V. fischeri* toxin (red) being loaded by a putative chaperone (blue) onto the tip of the T6SS weapon (green).

Using Geospatial Data to Better Public Health

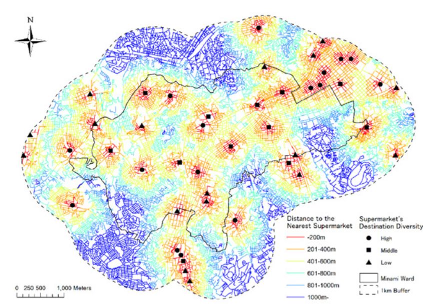
Wataru Morioka, Geography & Geosciences

My research field is geographic information science (GIScience), which focuses on the methods and techniques used to acquire, process and analyze geospatial data. By developing and applying new GIScience methodologies, I aim to better understand urban structures and human mobility.

I have been exploring how cities and their components behave, evolve and impact our daily lives, with a particular emphasis on public health and commercial environments. For example, in a study on walkability, I analyzed the relationship between older adults' daily step counts and their proximity to grocery stores in Yokohama, Japan. The findings indicated that older women living within a quarter mile of the nearest grocery store tended to walk more. Promoting walkable environments is especially important in aging societies like Japan, as it encourages healthy lifestyles, supports aging in place and helps reduce social care costs.

From a methodological standpoint, my work is characterized by the use of network spatial analysis, which assumes a network-constrained space and measures distance based on the shortest path or travel time, rather than traditional 2D plane measurements. This approach is particularly suitable for urban studies since spatial events and human mobility are often constrained by street networks. My walkability study, mentioned above, also used shortest-path network distances to assess spatial access.

The topics I have been working on include environmental health, business locations, transportation, etc. While the subjects are diverse, these projects share a common goal: to provide new insights that can inform decision-making processes aimed at solving social problems and improving everyday life. I was drawn to Salisbury University because of its exceptional strengths in my research field. I am excited to collaborate with other researchers on campus!



Cited from Figure 3, "Visualization of street-network distance from the nearest supermarket", on Morioka et al. (2023). Morioka, W., Kwan, M. P., Hino, K., & Yamada, I. (2023). How accessibility to neighborhood grocery stores is related to older people's walking behavior: A study of Yokohama, Japan. *Journal of Transport & Health*, 32, 101668.

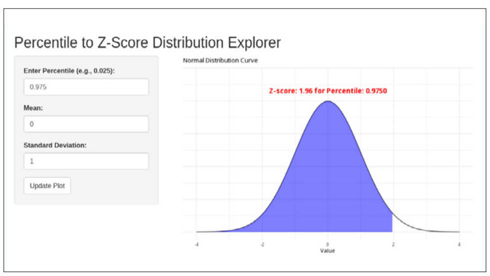
Transforming Concepts Into Discussions

Deepak Bastola, Mathematics

Education is constantly evolving to meet the challenges of a changing world. In recent months, I have dedicated my efforts to enhance traditional teaching methods by integrating technologies that not only captivate but also actively involve our students. My strategy involves the development of HTML-based interactive slides, pre-distributed to students to allow a seamless transition into classroom discussions. This method transforms mathematical concepts into tangible, dynamic discussions, enriching the educational experience within the limited time of classroom interactions and encouraging students to revisit and reflect on the material independently.

For these innovations, I have employed R (a statistical computing software) and Posit (an interface to R) to make the slides and interactive webpages, with GitHub (a developer platform) serving as the platform for storage and hosting. This setup integrates flawlessly with our MyClasses system, affording students straightforward access to learning tools within our current educational framework.

An exciting addition to our interactive content is the incorporation of Shiny apps into the lecture slides. These interactive dashboards, developed using R, enable students to engage with the data in real-time, enhancing their learning experience (as illustrated in the graph below.)



Beyond classroom instruction, I am concluding my research collaborations with former students with publishable research articles and actively investigating visualization techniques and exploring properties of vine copulas for multidimensional time series representation. Additionally, I am actively seeking to recruit new students for upcoming summer research opportunities at SU. These efforts complement my passion for interdisciplinary student research.

I also aim to use my background in astrophysics, mathematics and statistics to develop and supervise student-led research in astrostatistics. By leveraging freely available data sources, we will quantify uncertainty in astrophysical phenomena or parameters of interest using statistical methods. The focus will be on employing techniques that are easily accessible to students, fostering an environment where they can actively engage in significant research projects from the ground up.

My current class webpages that showcase my teaching innovations are available at **https://math216-fall24.netlify.app/** and **https://math313-fall24.netlify.app/**. My current webpage is: **https://deepbas.io/**.

I'm also proud that five students that I co-supervised won first place at the MUDAC Data Analytics Competition (click on 2024 winners to learn more: **https://www.mudac.org/mankato/**).

Exploring Viral Relics

Guney Boso, Biological Sciences

My research at Salisbury University is focused on exploring the fascinating world of endogenous retroviruses (ERVs), remnants of ancient viral infections that make up about 8% of the human genome. These viral relics originated from ancient retroviruses (distant relatives of HIV, the causative agent of AIDS). Retroviruses are unusual among animal viruses in that their viral life cycle includes the integration of DNA copies of the viral RNA genome into host chromosomes. On rare occasions, retroviruses can infect germline cells (sperm or egg) or their precursors which can lead to the transmission of the retroviral DNA to the next generation. These genomic fossils of ancient infections were originally dismissed as "junk" DNA, but they recently have been shown to add new layers of complexity to vertebrate genomes, with some still retaining functional genes that may play important roles in vertebrate biology.

I take a multidisciplinary approach to this work, using bioinformatics, phylogenetics and molecular biology techniques to examine how ERV genes have been domesticated in vertebrate genomes. My research spans several projects that focus on identifying preserved ERV genes in vertebrates, with a particular focus on mammals, understanding their evolutionary history and uncovering their potential functions. A key aspect of my research is its accessibility to students. Students at SU will be involved in all stages of the research process, from genomic screens and phylogenetic analysis to functional assays of ERV genes. These projects provide students with hands-on experience in cutting-edge molecular biology and bioinformatics techniques while giving them a sense of discovery and fostering their development as independent researchers. My goal is to guide the students at SU as they explore the fascinating world of evolutionary genomics and contribute to the understanding of how these viral remnants have shaped vertebrate biology.

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