PURDUE UNIVERSITY | The Graduate School

InnovatED

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A LETTER FROM THE DEAN

Dear Purdue Community,

When we launched our first issue of InnovatED in August 2020, our mission was to showcase the influential and inspirational graduate research conducted at Purdue University. However, as we approach publishing our third issue of this magazine, it has become abundantly clear that we've inadvertently captured something else – a generation of scholars dedicated to solving today's toughest challenges.

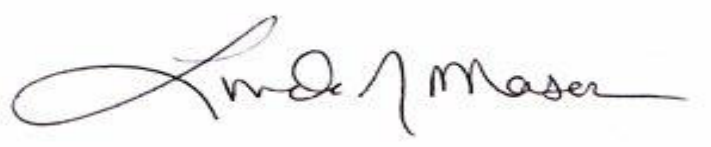
It is no secret that we are living in trying times. Whether it be the COVID-19 pandemic, climate change, or social unrest, our collective trials can sometimes seem daunting. However, humankind has proven time and time again that our most difficult moments often inspire our most extraordinary accomplishments, and graduate students at Purdue University perfectly exemplify this.

No matter the challenge, our students adapt and persist. They are dedicated to addressing today's biggest issues through their world-changing research. Whether they are discovering ways to mitigate the influx of dangerous counterfeit medical supplies during the COVID-19 pandemic, or developing self-aware industrial systems to combat hackers, or uncovering new, disease-resistant crops to feed our ever-growing population, it is clear that their work is the bedrock of our future.

While it is important to celebrate their accomplishments as researchers, it is also important to remember that graduate students are not just students – many are also teachers, contributing to the world-class education for which Purdue University is known – some are parents, skillfully balancing research, classes, and family. All are members of a community, just like you and me.

It is because of these connections that our students are driven to affect change. Through community outreach programs, like the Boilers Work Internship program, which provides graduate students with the funding necessary to pursue unpaid internships, many have leaped at the opportunity to make a difference both on campus and in their communities. This year, half of our Boilers Work award recipients chose to volunteer their time and share their expertise with hospitals and health departments around the country, during a time in which our health care system is in desperate need.

Despite the many difficulties that we have all faced these past couple of years, all Boilermakers have one thing in common – dedication to building a better world, together. That dedication is captured, perhaps better than ever, in this issue of InnovatED.



HEAD IN THE CLOUDS

BY: COLIN HAMILL

EXAMINING CLOUDS TO BETTER UNDERSTAND EXOPLANET ATMOSPHERES

Do you know how much an average Earth cloud weighs? Over one million pounds! Surprising right? The fact is that our clouds are made up of trillions of tiny water droplets floating around in Earth's atmosphere. These droplets scatter light in a way that makes them appear white/gray, creating the fluffy, deceptively heavy clouds that we all know and love. Just like how Earth clouds can limit our vision as we look up into the sky, clouds on distant planets can hinder our ability to look down into those planets' atmospheres. Exoplanet clouds, or clouds in the atmospheres of planets outside of our solar system, are often a nuisance for astronomers because they act as a shield around planets, limiting the information we can gather with telescopes.

Exoplanets span a wide range of sizes and temperatures, and their accompanying clouds vary, as well. Cold planets, with temperatures way below the freezing point of water, host clouds of methane and ammonia, while it is believed the hottest gas giants form clouds composed of diamonds and minerals. More temperate exoplanets with temperatures between 80 – 1300 °F may host clouds of water, potassium chloride, and/or zinc sulfide, just to name a few. Cloud particles on exoplanets can be liquid or solid; the solid particles can take on a variety of shapes, from sphere-like to rods to porous aggregates, similar to snowflakes. It is theorized that all these different cloud species may uniquely scatter light depending on their chemical properties, particle shapes, and particle sizes.

My research aims to characterize how these exotic cloud particles scatter light in the laboratory. Since clouds make it difficult to study an exoplanet's atmosphere directly, my work makes it possible to study the next best thing: the clouds themselves. If astronomers can characterize the cloud composition of an exoplanet based on its unique scattering fingerprint, this information can be used to infer the properties of the atmosphere that produced those clouds.

To see how cloud particles scatter light, I essentially create exoplanet clouds in the lab and shine visible (i.e., violet, green, and red) lasers at them. I then measure the brightness of the reflected light from the cloud particles at a variety of viewing angles. I create these laboratory clouds by aerosolizing particles from about 1 – 10 micrometers in radius, which is smaller than the width of human hair and invisible to the naked eye. These particles are then flown into the detection system using a nitrogen carrier gas with particle concentrations in the range of a few thousand particles per cubic centimeter. These particle sizes and concentrations are comparable to what we expect to see in real exoplanet clouds.

Currently, I am examining how clouds on temperate exoplanets with temperatures higher than that of Earth scatter light. My lab studies are especially useful for GJ 1214b, a potential "water world" which may host thick cloud layers of potassium chloride and zinc sulfide. My scattering data for potassium chloride and zinc sulfide can aid modeling efforts to better understand the structures of temperate exoplanet atmospheres and may allow us to identify the cloud composition of GJ 1214b in the near future.

My scattering results indicate that cloud particle scattering is more complex than assumed by models. Most models idealize cloud scattering by assuming the cloud particles in question are perfectly spherical. These models are also unable to account for cloud scattering when a variety of particle shapes and sizes are present. While these assumptions are somewhat acceptable for water droplets on Earth, cloud particles on other planets often take exotic, non-ideal shapes which impact how they scatter light. For example, our potassium chloride analogs resemble table salt and take cubic shapes; zinc sulfide particle analogs look like tiny popcorns at the microscopic level. By measuring how these particles scatter light under conditions comparable to an exoplanet atmosphere, my laboratory experiments help to fill in the knowledge gaps where idealized scattering may not be accurate.

My research is helping us better understand the many different types of clouds in the universe and the atmospheres that create them. For cloudy atmospheres, which are ubiquitous across planetary systems, it is impossible to understand the planet without understanding its clouds. As we begin the hunt for potentially habitable, Earth-like planets, it is clear that the key to discovering these planets may be hidden in the clouds.

ABOUT THE AUTHOR

COLIN HAMILL

Colin Hamill is a Ph.D. student in the Department of Earth, Atmospheric, and Planetary Sciences under the guidance of Dr. Alexandria Johnson. Colin works in the Johnson Cloud Lab to better understand the scattering and microphysical properties of exoplanet cloud particles. Before graduate school, he earned a B.S. in Physics from Towson University and interned at the Applied Physics Laboratory. In his free time, he enjoys exercising and hanging out with his cat, Tuba.

COVERT COGNIZANCE

EMBEDDING INTELLIGENCE IN INDUSTRIAL SYSTEMS

BY: ARVIND SUNDARAM

Picture the scene from the movie Independence Day (1996) where a team of scientists capture and reverse-engineer an alien spaceship enabling Will Smith and Jeff Goldblum to fake their way into the mothership. An alien operator grants them access on the mistaken belief that the spaceship is genuine. That movie could have ended very differently if the mothership was self-aware enough to distinguish fake from real instead of trusting the alien operator that proved to be its undoing.

Analogously, critical industrial systems in real life often face the same conundrum with an inability to distinguish between covertly falsified data and genuine operational data. As modern industry embraces digitalization, the increased interconnectivity of "smart" devices often creates multiple avenues for malicious agents to remotely interact with industrial systems and cause physical damage. The replay attack, popularized by the Stuxnet virus in 2010, greatly exploited this observation by replaying past data to mislead operators and statistical detectors while it covertly destroyed several centrifuges at the Natanz nuclear facility in Iran. While many security paradigms have been proposed since, my research identifies a key gap in that these measures are often trust-based, like the alien operator, or can be reverse-engineered by knowledgeable adversaries, like the scientists in Independence Day.

My present work, Covert Cognizance (C2), fills this gap by inducing self-awareness (cognizance) in industrial systems in a discreet manner (covert). It serves as an additional layer of defense at the process level when security measures such as passwords, biometrics, communication protocols, hardware signatures, etc. have been bypassed by sophisticated adversaries. While existing systems follow a

"do-as-told" philosophy, in C2, the goal is to make them intelligent without relying on human factors or pre-defined human logic on what constitutes "genuine data". This intelligence permits automated intrusion detection and self-healing mechanisms, where a compromised system can detect data falsification, recover the original data, and continue to operate while ignoring the falsified input and relying on its own memory instead. This is markedly different from current security mechanisms where industrial systems are often shut down in response to a cyberattack until a forensic team is able to isolate the attack, protect the system, and restore system function.

To achieve the aforementioned cognizance goals in a covert manner, the C2 paradigm identifies two key criteria, namely, zero-observability and zero-impact. The zero-observability criterion is motivated by the fact that overt security measures are well-understood and can be reverse-engineered and/or bypassed as mentioned in the previous paragraph. To be truly covert, a system must operate identically with and without the C2 mechanism in place, and an external malicious agent interacting with the industrial system must be unable to detect its presence by observing the industrial data. The zero-impact criterion is similarly motivated by the fact that existing layers of security often hinder system performance through the introduction of additional protocols, log files, extraneous variables, etc. that manifest themselves as additional overhead costs.

In my research, I protect the data in a nuclear reactor from being falsified by attackers that may wish to mislead operators into taking dangerous actions such as increasing the reactor power beyond the permitted range and causing a meltdown. By sticking to the zero-impact and zero-observability principles, I secretly store information about the reactor power in other modules like the steam generator which measures the water and steam level. This way, if the actual power data is falsified, I can instantly detect intrusion because the falsified data does not match with the information stored in the steam generator. Furthermore, I can now recover the actual power data from the steam generator to continue operation of the reactor while a cybersecurity team deals with the intrusion.

Covert Cognizance's flexibility and artificial intelligence capabilities have huge implications for the future of system security. Self-aware industrial systems can minimize operational and maintenance costs, decrease the reliance on human personnel and subsequently minimize the risk due to human error. While my work explores cybersecurity applications, C2 could impact a number of areas including but not limited to stealth communication, fraud detection, and fingerprinting. So, while the aliens in Independence Day may have failed to distinguish between fake and real, we don't have to.

ABOUT THE AUTHOR

ARVIND SUNDARAM

Arvind Sundaram is a Ph.D. Candidate in the School of Nuclear Engineering at Purdue University. Having completed his bachelors in the same in Spring 2019, he started his graduate career in May 2019 in the field of cybersecurity with his advisor, Dr. Hany Abdel-Khalik, and has authored multiple publications focused on intrusion detection and data masking in industrial systems. In his free time, he enjoys watching cricket and professional Dota 2 tournaments.

UNCOVERING

NEW DISEASE RESISTANCE FOR CHEAPER AND CLEANER AGRICULTURE

BY: CHRISTOPHER DETRANALTES

Have you ever had the unfortunate experience of dealing with sick and dying houseplants? Or maybe you've felt the burden of plants lost to disease in your garden or on the family farm? These all-too-common woes are shared by many as their first introduction to the topic of plant pathology, the science of plant diseases. Just like animals, plants get sick too! Finding new ways to prevent and treat plant diseases, which can lead to annual losses in the billions of dollars for a given crop, is an important task for all sectors of agricultural research and development.

Currently, a major component in the management of economically relevant diseases is to spray plants with chemicals that inhibit a potential pathogen's attack and spread, much like a physician preventatively prescribing antibiotics for a patient. However, increasing concerns over the environmental pollution associated with largescale applications of preventative pesticides and rising demand for organic agricultural products mean sole reliance on agrichemicals is hardly a sustainable strategy moving forward. The cost of continuously spraying pesticides and evidence of the development of pesticide resistance within pathogen populations further shortens the lifespan of such a near-sighted strategy.

Luckily, plants have pretty incredible natural immune responses to fight off would-be pathogens. So, hope remains for developing sustainable disease management! The deployment of genetically durable resistant lines and varieties is key to offsetting the current dependence on pesticides. Resistant varieties prevent infection by potential pathogens or mitigate the impact of the pathogen on the host after infection, much like vaccinated individuals resist infection and disease.

Unfortunately, many natural disease defenses were lost as the demand for higher yielding plants limited the genetic diversity of crops selected to be grown. Even in the era of "-omics," defined by ever-cheaper applications of molecular and DNA technologies, we still lack sources of known genetic resistance for many of the most predominant agricultural pathogens robbing us of our crop yields

every growing season. For farmers, this means that the ability to select a variety resistant to the most common plant diseases in their area is at best limited and at worst not even possible.

For the past two and a half years, I have been studying the enormously costly soybean seedling disease complex, which infects vulnerable seedling's roots and often kills plants before they have a chance to produce any grain at all. In the past two decades, the causal pathogens of this disease have been the second leading cause of yield losses across soybean-producing regions in the United States and Canada. Losses for the state of Indiana alone are estimated at over 420 million USD! Currently, no line or variety has been developed with enough genetic resistance to subvert these losses largely due to a lack of known resistance.

My research has focused on the identification and characterization of genetic resistance to the three predominant pathogens causing this disease. I collected and identified the pathogens from Indiana and Ohio production fields in 2019 and spent 2020 through 2021 conducting numerous rounds of varietal screening for resistance. The screening process involved selecting a bank of genetically diverse soybeans and testing them for their reaction when artificially inoculated with the disease-causing pathogens compared to non-inoculated controls. The ratio of the average root weight of an inoculated variety compared to the observed potential of its matched non-inoculated control provided a quantitative way to compare resistance between genotypes. Despite challenges imposed by the pandemic, the screening was completed and resulted in the identification of 30+ varieties with higher measures of resistance than any previously tested varieties. This milestone was important as the identified highly resistant lines may just hold the genetic keys to achieving the overall goal of disease management out in the field!

The journey isn't over for me yet... While decades of breeding efforts may have inadvertently led to some loss of genetic disease resistance in modern lines, they were ultimately guided by the needs of growers and society, as a whole. Traits affecting the ease of harvest, yield per plant, and more are critical features that dictate which varieties producers choose to grow. To better serve soybean producers, we need to transplant the resistance genes in our less productive varieties into the elite, higher-yield lines that farmers have grown to know and love.

With the continued support of my advisor, I have bred the populations of plants necessary to map the location in the soybean genome of the genes responsible for resistance. My next step is to identify the genes conferring the most resistance. This is a giant leap towards the shift away from total reliance on chemical pesticides toward more cost-effective, organic, and less polluting strategies to manage soybean seedling diseases through the application of natural plant genetics.

ABOUT THE AUTHOR

CHRISTOPHER DETRANALTES

Christopher Detranaltes is a Ph.D. student in the Department of Botany and Plant Pathology in Dr. Guohong Cai's soybean pathology lab. Prior to graduate school, Chris attended his home state's Arizona State University receiving a B.S. in general biology before moving to the 'breadbasket of the nation' to study his true passion, agricultural production and pest management. His research focuses on root diseases in soybean seedlings. Chris enjoys maintaining his army of houseplants and playing chess in his free time.

NATURE VS. NURTURE

EXAMINING HOW COW BEHAVIOR CAN CHANGE OVER A LIFETIME

BY: AMANDA BOTELHO ALVARENGA

Imagine you are a farmer rearing beef cattle with the ultimate goal of producing a remarkably juicy, flavorful, and tender steak. What characteristics or factors would concern you the most? Perhaps growth and meat quality are two traits that pop into your mind. However, in a recent national survey, cattle behavior was identified as one of the traits of greatest interest to farmers. Grumpy cows are more likely to injure cattlemen than their docile counterparts. In addition to the well-being of cattlemen, animal behavior is also associated with self-welfare, meat quality (e.g., better-quality steaks from more docile animals), and growth.

Dr. Luiz Brito, my advisor, and I partnered with the Angus Genetics Inc. team (Saint Joseph, MO) with the mutual interest of understanding beef cattle behavior and its dynamics across the lifespan of the animals. We asked the question: "Do the genetics of calm, cool, and collected cows differ substantially from those of their cantankerous counterparts?" Angus Genetics Inc. provided phenotypic (what we observe, e.g. weight), genotypic (DNA information), and pedigree (known family members) data from thousands of cows reared across the U.S. in order to investigate this issue. The behavioral indicator was temperament measured on a scale from one (i.e. very docile) to six (i.e. threatening to cattleman safety). Temperament was repeatedly measured on animals over the years from one to 15 years of age.
We observed that the temperament of one-year-old cows was affected, for example, by sex along with the age of the mother. On average, males tended to be less ill-tempered than females. In humans, women have higher rates of mood and anxiety disorders than men, while men have an increased risk of antisocial personality and substance use disorders. Secondly, in our dataset, younger cows raised more docile offspring compared to older mothers. We, therefore, hypothesized that calves could reflect the behavior of their mothers, whereby an older cow, through memory acquisition, would be more likely to become aggressive or fearful over time due to previous negative experiences.

Similar to some mental disorders in humans, behavior is moderately heritable (~40%) in livestock animals. That is to say, temperament is genetically passed from the parents to their offspring. It is worth highlighting that behavior is a complex trait with other factors playing an important role, including environmental factors or experiences to which an animal was subjected

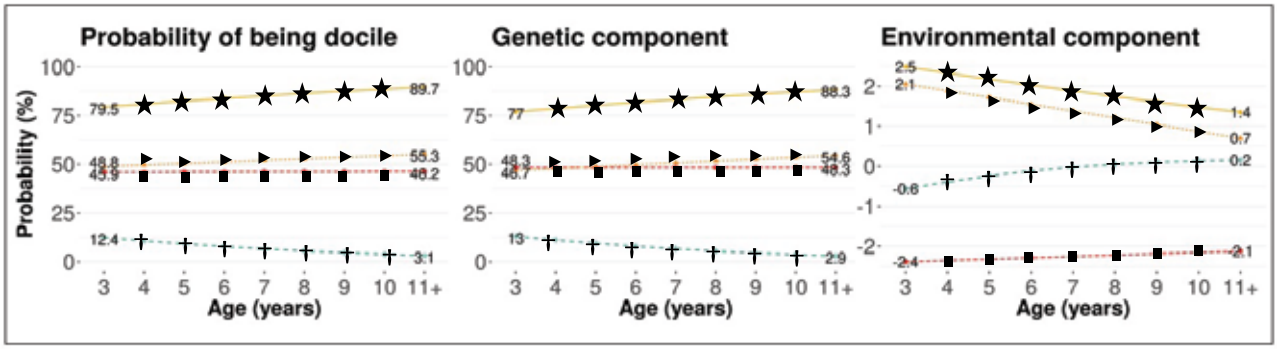
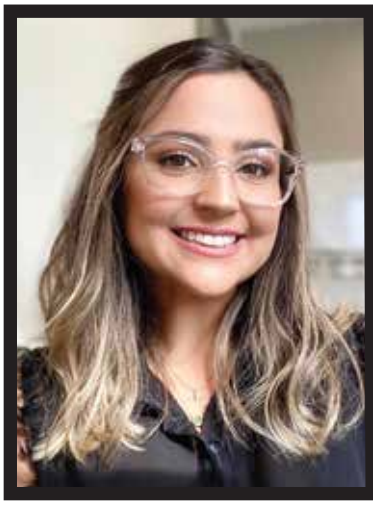


Figure 1. Probability of being docile across the years for four cows.

throughout its life. The follow-up study aimed to evaluate this memory acquisition or learning ability, and how the environment interferes with animal behavior across the years. We used complex models to evaluate the changes in animal temperament from genetic and environmental perspectives. First, we observed that animal behavior changes over time. In Figure 1, we plotted four cows with different dynamics of the genetic probability of being docile from three to 11 years of age. Greater probabilities mean that the animal is likely more docile. For instance, the yellow-solid-line cow has a probability from 79.5% at 3 years to 89% at older ages, suggesting that this animal is getting more docile over time ('Probability of being docile'; becoming a sweet elderly cow). Its genetic potential alone had a similar pattern (from 77 to 88%; 'Genetic Component'). However, over time, the experiences to which the yellow-line cow was subjected negatively impacted its behavior, reducing the docility probability by ~1% from three to 11 years old ('Environmental component'). A similar interpretation could be drawn for the other three animals.

We believe the rate of behavioral changes across the years could indicate the learning or memorization ability of cows. This ability could be broken down into two components: (1) genetic or the ability the cows inherited from the parents and (2) environment or the experiences they had throughout their lives. On average, docile cows have been shown to have a positive learning ability (becoming more docile) compared to aggressive cattle. We observed that the impact of the environment on temperament is likely independent of genetics. In other words, aggressive cows could potentially have positive experiences and, therefore, increase, at some level, their probability of being docile.

Angus stakeholders are interested in rearing composed cattle and improving animal welfare. We hope that this study will provide a better understanding of the factors underlying cows' temperament and assist with the genetic selection of docile animals to parent the next generation of cows. This knowledge can, ultimately, improve the overall well-being of both cattle and cattlemen. Further studies are currently underway to better illustrate this new concept of learning/memory ability in Angus beef cattle.



ABOUT THE AUTHOR

AMANDA BOTELHO ALVARENGA

Amanda Alvarenga received her B.S. and M.S. degrees in Brazil and since 2019 she has been working under Dr. Luiz Brito's supervision. Her research focuses on the integration of genomics, large-scale phenotypic datasets, and advanced statistical modeling to optimize genomic selection for improved cattle behavior and welfare. Alvarenga has published, during the Ph.D., two papers and one is under revision as the first author, and three papers as collaborators. In addition, Alvarenga has also served in multiple extracurricular roles in the Department of Animal Sciences, has contributed to the training of several undergraduate and graduate students, and has received five awards during her time as a Ph.D. student. She enjoys spending time with her family in Brazil, volleyball, and watching Purdue basketball.

GUT REACTION

Targeting Gut Microbiota to Reduce Aggression and Improve Welfare in Poultry

BY: YUECHI FU

As the world's population continues to grow, the demand for poultry products grows with it. To meet this constantly increasing demand, maintenance of birds in conventional cages has been a common management practice in the United States and most non-EU countries. Currently, approximately 74% of laying hens (249 million table-layers) are housed in cages in the United States. However, considerable welfare issues appear due to a mismatch between birds' behavioral needs and the restricted living space, such as increased incidences of aggression (Hartcher and Jones, 2017)

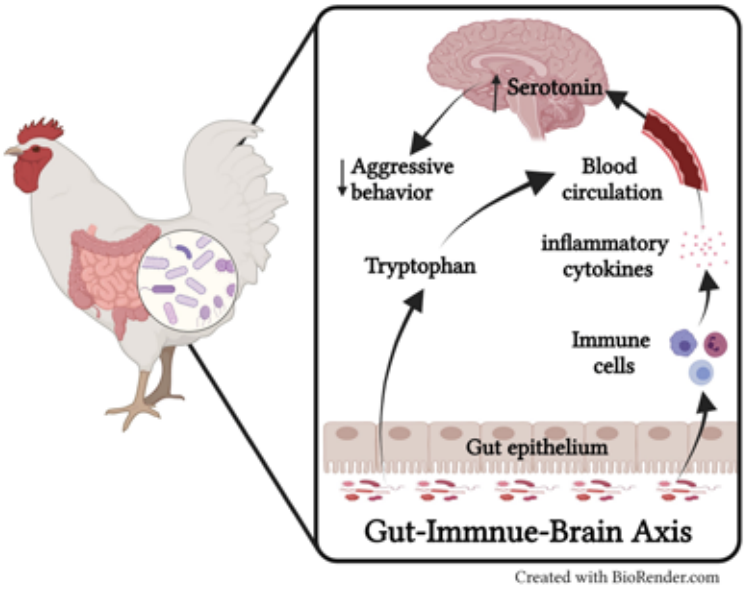
In egg-laying chickens, aggression can be characterized as one bird forcefully pecking at the head or neck of other birds. Pecking can transfer to other areas of the body if the pecker cannot reach a certain area (Dalton et al., 2003). From the standpoint of the evolutionary process, aggression serves an adaptive purpose since it promotes survival and reproduction within a group (Nelson, 2005). However, in artificially confined housing systems, aggression leads to feather and tissue damage, pain, and subsequently mortalities, which compromises poultry production, health, and welfare (Tablante et al., 2000). Thus, developing a reliable method to control aggression is necessary for improving the health and welfare of laying hens.

To achieve this goal, my research focuses on identifying a strategy to mitigate these aggressive behaviors. During the process of literature reviewing, a 'magic' bacteriotherapy in humans called fecal microbiota transplantation (FMT) attracted the attention of myself and my advisor, Dr. Heng-wei Cheng. This therapy transplants a mixture of feces from a healthy donor into a patient's gut to directly alter the gut microbiota of recipients to gain therapeutic benefits (Wang et al., 2014). Nowadays, FMT has been widely used in treating gastrointestinal diseases, with a potential for treating neuropsychiatric disorders (Settanni et al., 2021). One might ask "how could gut microbiota help in treating mental disorders?" This is because the gut microbiota, also functions as an endocrine organ, which helps produce mood-regulating hormones. It also communicates with the brain bidirectionally via the gut-brain axis by releasing various neuroactive compounds and neurotransmitters, which can regulate cognition, mood, and related behaviors (Roth et al., 2021). Serotonin, a key neurotransmitter in the central nervous system, plays a pivotal role in regulating aggression in humans and various species of animals including rodents and chickens (Dennis et

al., 2008; Bamalan and Al Khalili, 2020). Generally, increased aggressive behavior is associated with lower levels of serotonin (Beis et al., 2015).

The successful application of FMT in human trials led to the question: Can transplantation of gut microbiota be a potential strategy for alleviating abnormal behaviors and improving welfare in chickens? To test the hypothesis, we used inbred chicken lines 6_3 (gentle birds) and 7_2 (aggressive birds) as donors for collecting cecal content. Cecal content is from the cecum, which is the beginning of the large intestine. A commercial strain of chickens known as Dekalb XL (DXL) was selected as recipients for cecal microbiota transplantation (CMT). Briefly, there were three treatment groups: DXL control (without CMT), DXL-6_3 (received CMT from gentle birds), and DXL-7_2 (received CMT from aggressive birds). The transplantation was given via feeding needle for ten consecutive days, then once weekly for 3 to 5 weeks to boost the effectiveness of microbiota modulations.

Interestingly, the outcomes support our hypothesis that transplantation of cecal content from different chicken lines did affect recipient birds' behavioral patterns. The chickens that received CMT from gentle birds displayed significantly less aggressive behavior and higher concentrations of serotonin. This suggests that aggression could be reduced by transplanting the microbiota from gentle chickens. Furthermore, microbiota alterations influenced the immune response of recipient birds. In response to stress, DXL-6_3 birds (received CMT from gentle birds) had an improved immunological capacity than DXL-7_2 birds (received CMT from aggressive birds). Taken together, these results indicate that early postnatal CMT has the potential to reduce aggression and improve health in chickens through the regulation of the gut-immune-brain axis.



In the follow-up study, we hope to (1) determine the bacteria involved in regulating gentle or aggressive behaviors by comparing the gut microbiota compositions among different treatment groups, (2) identify the biochemical compounds synthesized by the revealed bacteria. With these aims, the determined bacterial strains will have the potential to be utilized as novel probiotics (or biotherapeutic agents) for improving the growth performance and production of chickens. Furthermore, the outcomes from this project will provide new insights for future research into the prevention of aggression in poultry and other farm animals, as well as promote the translation of technologies from academia to production.

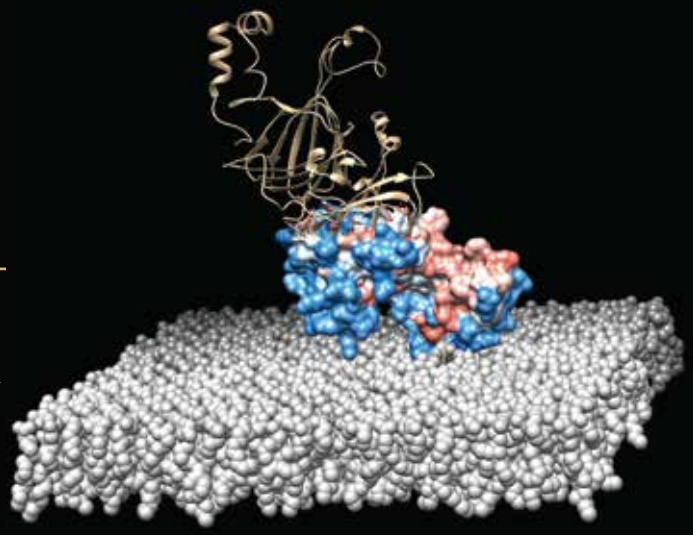
ABOUT THE AUTHOR

YUECHI FU

Yuechi is a master's student in the Department of Animal Sciences. She began her master's degree under the supervision of Dr. Heng-wei Cheng in 2019. Prior to graduate school, Yuechi completed her bachelor's degree in veterinary medicine from Southwest University in China. At present, her research focuses on modifications of injurious behaviors and physiological homeostasis in chickens through early postnatal cecal microbiota transplantation. After completing her master's degree, Yuechi hopes to continue studying microbiota-target therapies on improving wellbeing of farm animals.

ENGINEERING

PEA PROTEIN FOR MEAT AND DAIRY SUBSTITUTES



BY: HARRISON HELMICK & DR. JOZEF KOKINI

As the world's most populous countries undergo modernization, there has been a trend towards consuming more protein from animal sources such as beef, chicken, and dairy. However, increased animal-based protein consumption has led to decreases in available land for crops, additional greenhouse gas production, and added water usage. As the world's population trends towards 10 billion by 2050, the food industry faces the challenge of providing sustainable alternative sources of protein that are at least as attractive as current animal-based products. One group of proteins that has received careful consideration for meat and dairy replacement strategies are the proteins isolated from pulses, a category of legumes that are low in oil content.

Products like Beyond Burger™ and Daiya Brand Cheese have started using the protein isolated from peas, lentils, and other pulses in their products, and these brands have been met with enormous success amongst consumers, in part due to their marketing around sustainability. In a comparative analysis of the environmental impacts of a traditional burger versus a plant-based burger, it was found that plant-based burgers produced 90% less greenhouses gases, used 93% less land, and 99% less water. Nonetheless, these products are still met with some consumer hesitancy, in part due to the textures of the products, which often do not replicate meat and dairy well enough. My research focuses on how I can engineer the structure of pea protein, one of the most popular pulses, to better replicate the textures of meat and dairy analog products. To create the right mouthfeel, food scientists create gels and emulsions that mimic the chewy and smooth textures of meat and dairy that come from animals. All proteins are made up of twenty unique amino acids, and the order of these amino acids is the protein's primary structure which can be used to generate a three-dimensional (3D) model of the protein. In pulse protein, as well as other proteins, the gelation and emulsification properties come from the composition and order of amino acids, and models can help manufacturers understand the impacts their processing has on these properties. By first analyzing protein models, I have been able to identify new processing techniques which may lead to different textures and products that can be made using pea protein isolates.

In my research, I used a combination of structural bioinformatics and Python coding to

develop and analyze 3D structures of pea protein. I analyzed how these structures might change as the result of processing under high heat, high shear (in a blender), low temperature, or high-pressure conditions. The amino acid sequence of pea protein is comprised of about 34% hydrophobic amino acids, and these tend to locate themselves on the interior of the protein structure. Denaturation, which happens when the protein loses its native structure, breaks down the protein, and exposes the hydrophobic amino acids. This exposure leads to increases in the amount of oil that the proteins are able to emulsify. Emulsions made with these denatured proteins are able to keep fat droplets smaller, which is more consistent with the fat that is found in meat and cheese, allowing for better textures for consumers.

I have also found that how the protein denatures can lead to different structures of protein, some of which are better suited for emulsification, while others might form better gels. In my work, I have found that a combination of cold denaturation and shear forces, in particular, can lead to enhanced emulsification properties. By studying the fundamental mechanisms involved in cold denaturation, I have been able to generate models of potential pea protein structures after processing at low temperatures with applied shear forces. These were then validated through a variety of materials characterization techniques which showed that the protein was functionalized at low temperatures and had better emulsification properties.

In future work, I would like to scale my processing methods by optimizing my cold denaturation methods in extrusion, a process that involves passing material through a tube using a screw to move it and apply shear. By extruding pea protein at temperatures below negative five degrees Celsius, I will be able to realize many of the same benefits that I found in the lab. This will allow food processors to not only have access to a new tool for protein functionalization, but they will also be able to process heat unstable ingredients at the same time as the protein, leading to new gels, emulsions, and textures in food.

By starting with bioinformatic models, it is possible to analyze food proteins of interest before processing ever occurs, which can help the food industry save tremendous time in their research and development phases, as well as identify the best proteins for particular uses. In my work, I have shown that bioinformatics can be used to uncover a new processing technique that is based on cold denaturation, leading to better potential textures in meat and dairy analog products.

ABOUT THE AUTHOR

HARRISON HELMICK

Harrison Helmick is a Ph.D. student and Ross Fellowship Recipient (Fall 2019) in Purdue's department of Food Science where he studies under the direction of Dr. Jozef Kokini, Scholle Endowed Professor. He also mentors two undergraduate researchers, Sarah Ettestad and Christabel Hartanto, and they both make significant research contributions to his work and the lab. His work focuses on generating relationships between bioinformatic models of protein and textures in food. When he isn't in the lab, Harrison enjoys running and biking, and is almost always training for the next race. After graduation he hopes to work in the food industry as part of a team that uses data science to understand their research and design of new food ingredients.

TITLE IX ON TRIAL:

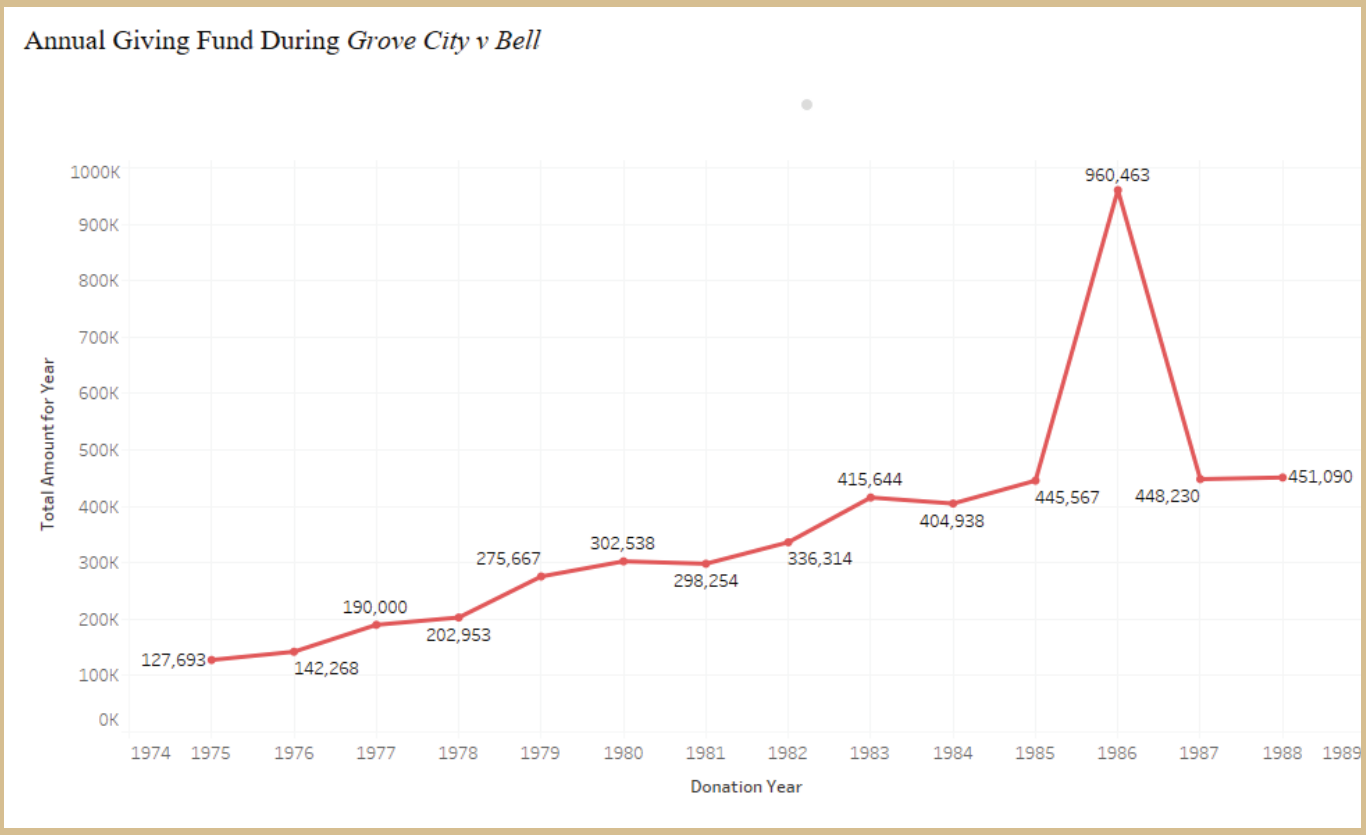
Philanthropy, Curriculum, and Politics in Grove City College v. Bell (1984)

BY: DEVAN LINDEY

In 1977, Grove City College in western Pennsylvania began a legal dispute with the Department of Health, Education, and Welfare (HEW) that took seven years and the Supreme Court of the United States to finally settle. In a case that gained national media attention—and sparked protests across the political spectrum—the small religious school argued that it did not fall under Title IX jurisdiction as a private institution. The school asserted that, since it did not accept direct federal funding, it did not need to sign an assurance of compliance form saying it did not discriminate based on sex. If they signed, college administrators argued, they would be subject to future regulations from the federal government, effectively signing away their independence. However, some of its students used public dollars in the form of Basic Educational Opportunity Grants and Guaranteed Student Loans to pay their tuition, ultimately launching a political and legal debate about the reach of the federal government into private institutions based on the form of funding received. If they did not sign, the government would withhold funding from those students.

As a historian, this case made me question the purpose of education and how philanthropy influences the curriculum of private institutions. And so, I examined speeches, letters, student handbooks, legal briefs, and the student newspaper to explore the intellectual, political, and curricular roots of why Grove City College retaliated. I found that it sought to defend a Judeo-Christian, economically libertarian, and culturally conservative form of education brought about by the philanthropy of the Pew family. My research reveals the complexity of higher education through politics and jurisprudence. This case illustrates that there has always been friction between private ideologies and public regulations, a friction that persists today in public schools around the nation.

When J. Howard Pew, president of the Board of Trustees, interviewed Charles MacKenzie for the position of President at Grove City College in 1971, he said to MacKenzie, "'You are my last hope for a renewal of Christian teaching and morality at Grove City. If you don't succeed, I probably will sever ties with my school'."[1] Pew's religion, business practices, and politics deeply shaped the development of the university as a bastion of conservative, Judeo-Christian education. Pew's philanthropic legacy helped to influence curriculum changes, notably courses that involved the Bible, religion, Austrian economics, and the role of freedom in the



"This case illustrates that there has always been friction between private ideologies and public regulations, a friction that persists today in public schools around the nation."

prosperity of America and business.[2] But such donations also shaped social life on campus. Required chapel attendance enforced the Christian atmosphere and the men's and women's dormitories sit on opposite sides of the campus to promote a set of social norms about male and female interaction.[3]

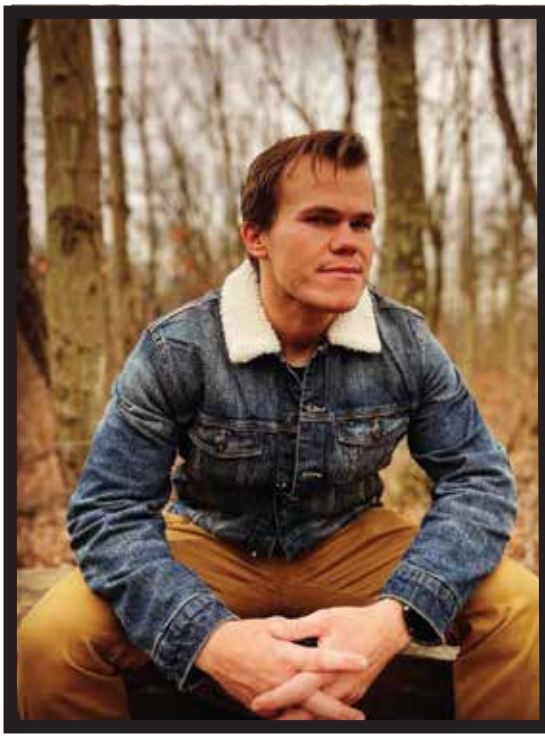
The court case exposed the ways in which Pew and the Board of Trustees attempted to use money to advance an ideologically-driven education environment on campus. For Pew and administrators, government regulation meant secularization, ultimately challenging their intentions for society via education.[4] Alumni bought into this framing, increasing their donations during this time to pay litigation fees and, eventually to replace student grants with private funds after the Supreme Court ruled on the side of the Department of Education (Figure 1[5]).

As a well-publicized legal battle about control over education and curriculum decisions, this case tapped into larger political conversations about civil rights and the role of the regulatory state. Many Conservatives hoped that the Reagan administration would drop the case, as Reagan ran on the promise to abolish the Department of Education and to decrease government spending and involvement in private life. And yet, the Department of Justice wanted to appease both Democrats and Republicans by reinterpreting Title IX to be program-specific, a change from the Nixon, Ford, and Carter administrations. Rather than operating with blanket coverage by which if one arm of an institution discriminated then federal funding would be withdrawn entirely, Title IX

would only apply to a specific program or activity of an institution that received federal funds, sparking fears from women's rights and civil rights activists that discrimination in classrooms would occur if only the financial aid office were covered. The Supreme Court ruled in favor of the Reagan administration's interpretation of Title IX which sparked a bipartisan backlash in Congress. As a result, Republicans and Democrats came together to overturn the Grove City decision in the form of the Civil Rights Restoration Act of 1987.[6] Their motivations may have been different with moderate Republicans seeking votes in an election year and Democrats defending minorities, but the result was a return to pre-Grove City decision standards by which a whole institution must comply with civil rights laws.

Today Grove City's think tank, The Institute for Faith and Freedom, continues to celebrate "freedom and faith," but it does so by relying on private donations and its historical ties with conservative ideals of independence, thus advancing a specific education for student fellows and projecting their values onto society.

Grove City's political and legal battle reminds us of the politics shaping debates over curriculum and the higher education experience today—from COVID-19 regulations to conservative critiques of Critical Race Theory to the introduction of the Civics Literacy Proficiency requirement here at Purdue. The Grove City College v. Bell (1984) case illustrates the friction between private ideologies and public regulations that persists today. It also reveals that education is much more than curriculum and pedagogy, but a whole experience shaped by the campus on which students reside.



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DEVAN LINDEY

Devan Lindey is a Ph.D. Candidate in the History department. He studies education, legal, and political history. His publications include pieces at History News Network, Public Seminar, and a blog post for Memoirs & Memories: Tales From Purdue University Archives and Special Collections. Devan's advisor is Dr. Pitts in the History department. He also works with Dr. Brownell and Dr. Gabin.

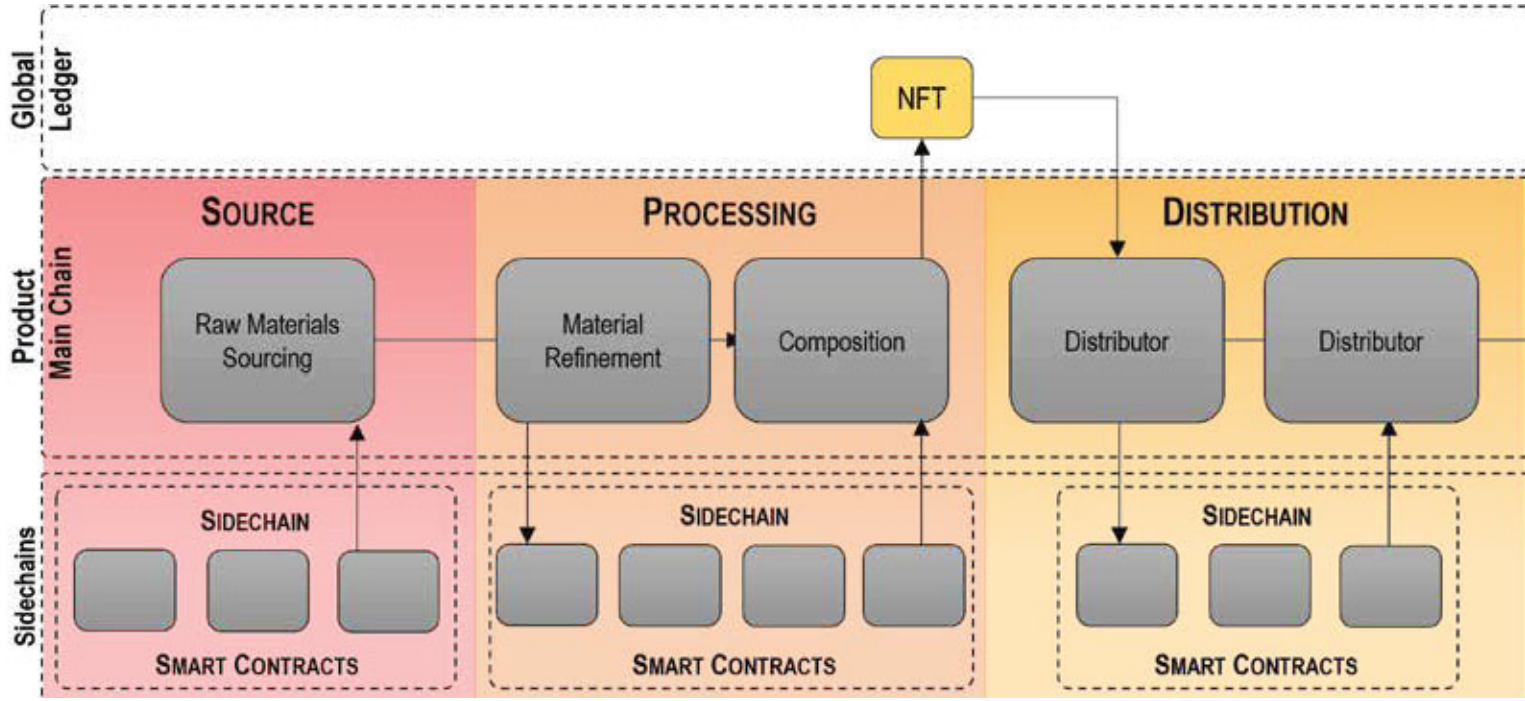
ASSURING MEDICAL SUPPLY CHAINS

WITH DISTRIBUTED LEDGER TECHNOLOGY

BY: ALEXANDER MILLER

Medical supply chains are impacted by several major factors. Continuous change in medical technology and investments in medical innovation (Institute of Medicine (US) Committee on Technological Innovation in Medicine, 1995), man-made events, such as the terrorist attacks in the United States on February 26, 1993, and September 11th, 2001, or the massive industrial explosion in Beirut, Lebanon on August 2nd, 2020 can spontaneously generate enormous demand for medicine and medical supplies in a concentrated area (Amlôt & Holtmeier, 2019; Centers for Disease Control and Prevention, 2021). Natural phenomena, such as disease, can generate spontaneous increases in demand for medical supplies, which can stress supply chains. To quantify this spontaneous stress to supply chains, the demand for N95 respirator masks reportedly increased by 1700% in the first months of the COVID-19 pandemic (Adhanom et al., 2020).

During times of increased demand, such as the rapid onset of a pandemic, supply chains are often unable to respond quickly enough to meet the new level of demand. This difference between what's available and what supplies are needed to contain the spread of disease and protect medical workers increases strain on the logistics, information, and material goods flows within supply chains (Dasaklis et al., 2012). These stresses on the medical supply chain create opportunities for grey markets to emerge and for



counterfeit, substandard, and falsified goods to enter the supply chain.

In 2011, the Office of the United States Intellectual Property Enforcement Coordinator highlighted that "Counterfeiting costs U.S. businesses more than $200 billion each year and accounts for the loss of more than 750,000 American jobs" (Office of the United States Intellectual Property Enforcement Coordinator, 2012). The International Chamber of Commerce estimates that, by 2022, counterfeit products will make up $991 billion of international trade, will displace between $980 and $1,244 billion in legitimate economic activity, and will put between 4.2 and 5.4 million jobs at risk (International Chamber of Commerce, 2016).

Demands for personal protective equipment (PPE) created an opportunity for counterfeit PPE to flood the market. In March of 2011, one incident led to the seizure of over 40,000 counterfeit drugs. In 2020, the United States Customs and Border Protection (CBP) seized millions of pieces of counterfeit medical equipment, including 107,300 Food and Drug Administration (FDA) prohibited COVID-19 test kits, 750,000 counterfeit face masks, 2,500 Environmental Protection Agency (EPA) prohibited anti-virus lanyards, and 11,000 FDA prohibited chloroquine tablets (U.S. Customer and Border Protection, 2020). Looking more broadly, CPB conducted over 23,700 seizures of counterfeit goods in the United States, valuing over $1.2 billion in fiscal year 2020 (October 1st, 2019, through September 30th, 2020) (U.S. Customs and Border Protection, 2021).

Counterfeit medical goods are not a new situation. A World Health Organization report noted that China, a major producer (Lewis, 2009; Mackey et al., 2015) and exporter of counterfeit goods, self-assessed that 8% of the Chinese over-the-counter drug market was counterfeit (International Medical Products Anti-Counterfeiting Taskforce, 2006). WHO further noted that upwards of 30% of medicines sold in Asia, Africa, and Latin America are counterfeit (Blackstone et al., 2014).

The broad problem addressed by my research is combating the production and distribution of falsified, substandard, and counterfeit medical goods in the medical supply chain.

One possible solution to this problem is the application of Distributed Ledger Technologies (DLT). Distributed Ledger is a distributed system for recording transactions pertaining to the exchange of assets between asset holders. The distributed nature of the system allows each node, or computer in the network, to vote on and validate new transactions through a consensus mechanism. While the ledger is distributed, it is replicated at each node in the network, providing resiliency from external or malicious manipulation. The resiliency comes not only from the distribution of

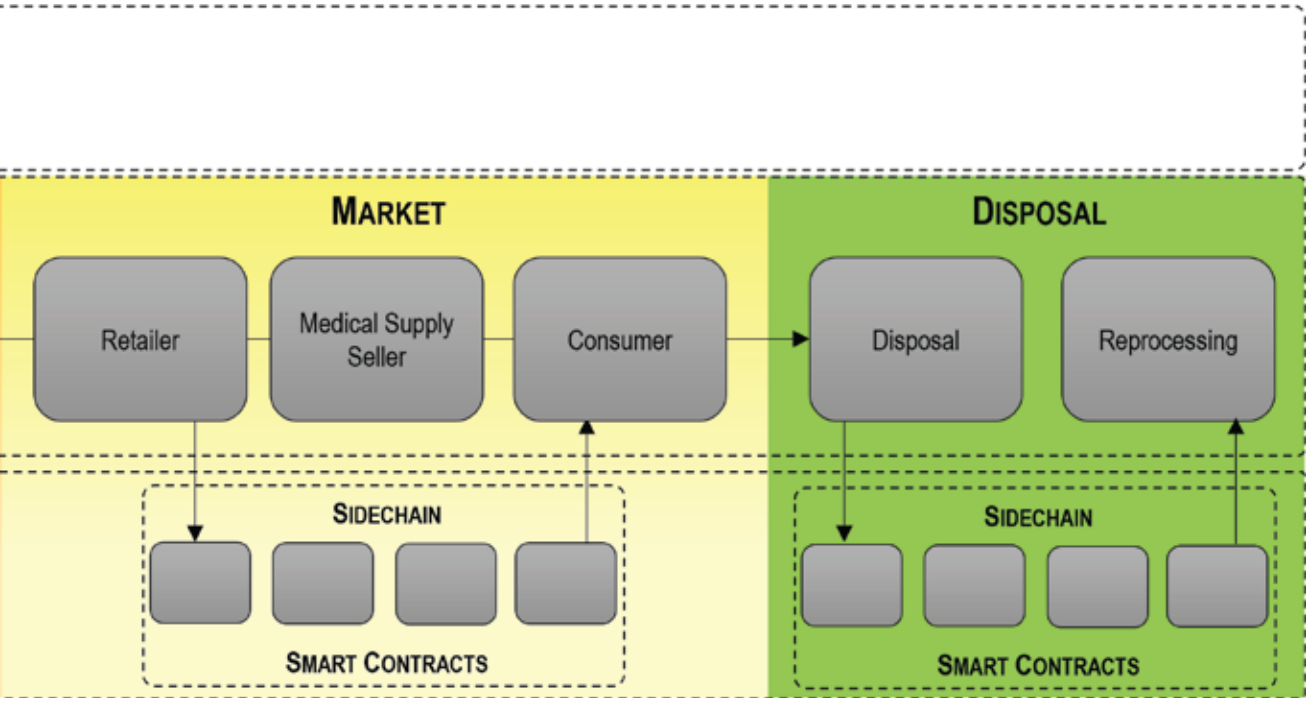


FIGURE 1: DLT Blockchain and Sub chain architecture applied to medical supply chain.

information, creating conditions where malicious actors would have to simultaneously change 51% of independent ledgers to create doubt, but also how information is stored in the ledgers. Each transaction and each block is stored with a cryptographic hash, or unique fingerprint, of the previous block, which acts as a digital key. This chaining of the data is the origin of the term blockchain. The popular implementations of distributed ledger technology include Bitcoin and Etherum cryptocurrencies, as well as emerging non-cryptocurrency implementations such as MedChain for medical records management (Daraghmi et al., 2019; Shen et al., 2019) or MedLedger for pharmaceutical traceability (Uddin, 2021)

Applying DLT to the medical supply chain would allow each step in the process to be appended to the final product, allowing blocks of work to prove the quality and validity of a product from the sourcing of raw material through the disposal of goods. Non-fungible tokens (NFT), units of data that certify the uniqueness of an asset, could be generated on the blockchain for physical assets to validate their quality and authenticity. Figure 1 shows this process, aligned to the supply chain, for applying distributed ledger, side chains for smart contracts, and generating NFTs as part of this research. Each step can be configured and tuned based on policy, legal, and market demands.

Take, for example, masks. Mask manufacturers may certify the production quality of their masks by attesting to adherence to best practices and appending that mask's lot number to a public ledger. Mask manufacturers could also develop production quality standards to automatically validate compliance with government standards (Centers for Disease Control and Prevention, 2022) which would be uploaded to the public ledger. PPE suppliers could also generate non-fungible tokens (NFT), a digital match to their physical goods, for consumers to check the exact details of when, where, and who manufactured or distributed the medical supplies. This would help ensure that medical supplies are not counterfeit.

Research into this problem shows that the medical supply chain is ripe for exploitation by counterfeiters and fraudsters. The lack of transparency and general sense of urgency when responding to crises creates opportunity for bad actors to inject fake or falsified products, which put the public at risk. Efforts to decrease information asymmetry between all parts of the supply chain, but most importantly between consumers of medical supplies and the rest of the supply chain, have focused on policy and prevention. Technology such as DLT could allow consumers, hospitals, and medical professionals to trust and validate the pedigree of medical supplies, as well as identify counterfeiters before counterfeit medical supplies spread or lead to injury.

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Alex Miller is a student in Purdue Polytechnic's Doctorate of Technology program. Alex is a graduate of Purdue University's College of Technology and has been published through the Purdue University Center for Education and Research in Information Assurance and Security. He has a Master's Degree in Systems Engineering from Johns Hopkins University. Outside of his professional career Alex supports his community by mentoring middle schoolers in Computer and Cyber security, supporting philanthropic events within the community, and participating in Ultra and Endurance activities.

POISON OR CURE?

A LIFECYCLE EVALUATION OF SHARED MICRO-MOBILITY'S CONTRIBUTION TO CLIMATE CHANGE

BY: HAO LUO

From storms and flooding to heatwaves and wildfires, U.S. cities are facing the severe consequences of climate change and global warming. The transportation sector has become the largest greenhouse gas source in the U.S., contributing 29% of the annual emissions. The continuous urbanization and population growth in the next decade are expected to increase residents' travel demand and greenhouse gas emissions, speeding up the global warming trend. Climate change mitigation actions in the transportation sector are urgently needed to guarantee livable conditions for U.S. residents.

Shared micro-mobility, a revolution in current urban transportation systems, introduced new possibilities to reduce greenhouse gas emissions. Shared micro-mobility systems enable users to have access to shared vehicles, such as bikes, e-bikes, and e-scooters, for a short period, on an as-needed basis, without requiring ownership. Since 2010, over 203 U.S. cities have developed shared micro-mobility services. One of the main motivations for cities to develop such systems is to reduce greenhouse gas emissions. Encouraging shared micro-mobility usage could potentially reduce car trips and avoid emissions from fossil fuel consumption.

But can shared micro-mobility guarantee climate change mitigation? This is not always the case because this emerging transportation mode is not "zero-emission" for three main reasons. First, manufacturing shared infrastructures (e.g., stations, docks, PV panels, batteries, shared vehicles) can generate a large number of carbon emissions. Second, daily operation, especially vehicle rebalancing (moving shared vehicles to under-supplied regions with trucks) and electricity charging (to power e-bikes and e-scooters) may also generate emissions. Considering the embedded emissions, shared micro-mobility itself could be another polluter. Third, the emission reduction benefits depend on whether customers use the service to replace car trips. But very likely, customers may use it to replace walking, which brings no emission reduction

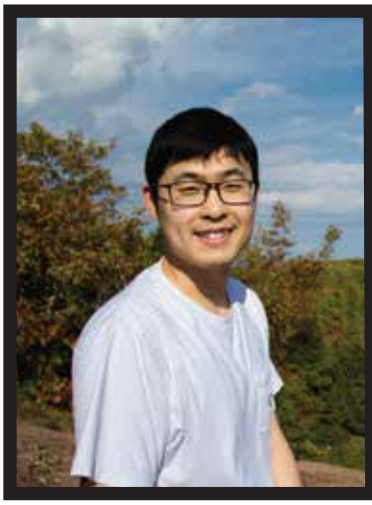
benefits. Whether current shared micro-mobility systems can contribute to global warming mitigation is still unclear.

To answer this question, my research evaluated the greenhouse gas emission and reduction effects of shared micro-mobility systems, through a life cycle assessment. We tracked every possible emission, from cradle to grave, during the entire life cycle, including raw material extraction, processing, assembly, transportation, maintenance, daily operation, material recycling, and final disposal. Emission reduction was also analyzed, considering the possibilities of replacing car trips, walking or public transit. Over 20 U.S. cities were selected to conduct the analysis.

From the emission generation side, shared micro-mobility systems may not be better than traditional transportation modes. In some cases, emissions from riding shared micro-mobility are higher than taking a bus for the same distance. Vehicle rebalancing is the main reason. During the daytime, especially in peak hours, high-demand locations may have no available bikes or e-scooters to pick. Operators have to frequently redistribute the shared vehicles to meet service demands in different regions. Every two to three miles of shared micro-mobility trips could require one mile of truck transport to rebalance vehicles, which is not only carbon-intensive but can also cause traffic congestion. In addition, manufacturing new vehicles and facilities is another main contributor to greenhouse gas emissions. Operators often excessively launch shared vehicles beyond the demand, either because of aiming to dominate the market or overestimating customers' enthusiasm. What's worse, most shared vehicles can only survive about six to twelve months, because of severe abuse, abandonment, and theft issues, as well as lack of maintenance. A bad system design and operation management could turn shared micro-mobility into a new global warming source.

From the emission reduction side, the ability to replace car usage relies on cities' local transportation infrastructure and travelers' habits. Shared micro-mobility is more likely to connect with transit services in cities with well-developed public transit infrastructure. Solving the first/last-mile issues, shared micro-mobility can extend the public transit service. Such an integrated trip has high potential to replace car trips and reduce greenhouse gas emissions. However, in some car-oriented cities, car replacement is limited, because shared micro-mobility can mainly cover short trips rather than long car trips. Customers in these cities mainly use shared micro-mobility to replace walking, which offers no emission reduction benefits. Guidance on customers' behavior and mode replacement are the key to mitigating climate change via shared micro-mobility.

My research findings indicate that shared micro-mobility systems could speed up climate change if the systems are not designed and managed well. To improve environmental sustainability, I proposed two strategies to help urban planners and system operators. First, better facility maintenance, monitoring, and management can significantly extend the shared vehicles' lifespan. Second, carefully decide the number of vehicles needed and their location distributions to meet customers' demand. For we customers, riding shared micro-mobility to integrate with public transit and replace car trips can promote climate change mitigation.



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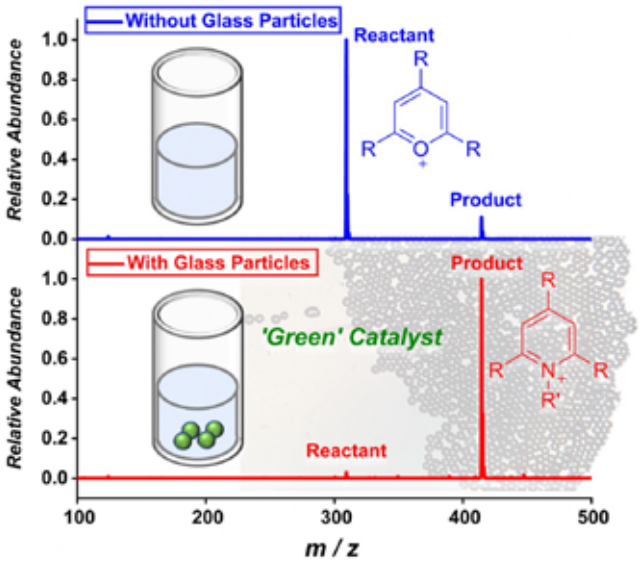
GLASS AS A GREEN CHEMISTRY CATALYST

BY: YANGJIE LI

Catalysts speed up chemical reactions, yet many catalysts contain expensive metals such as platinum or non-recyclable chemicals such as organic bases. A single load of a catalyst for industrial scale processes can cost as much as $1M. As part of the 'Green Chemistry' movement towards more recyclable and environmentally friendly chemicals, 'greener' catalysts have received growing interest and become a holy grail in chemistry. Recently, my colleagues and I in R. Graham Cooks' lab at Purdue University have observed a new phenomenon using our daily-use glassware as a powerful 'green' catalyst.

My journey in 'green' catalysts started with an unusual observation that the rate of a specific chemical reaction is boosted when it takes place in glassware, as opposed to plastic containers. This effect of glass-induced reaction acceleration was also shown by adding glass particles into the reaction solution; it was a great surprise to see that glass can speed up chemical reactions by up to a few hundred times. If the glass-induced acceleration effect is general for a broad range of chemical reactions, then tossing some glass particles into a reaction vessel and filtering them off at the end will dramatically reduce costs and allow us to avoid use of caustic or expensive chemicals. Glass would then be an inexpensive 'green' catalyst.



After our initial finding of the glass catalysis phenomenon, I moved on to investigate different reaction types affected by this phenomenon to gain a deeper understanding of how glass surfaces affect chemical reactions in general. Fortunately, our Purdue Make-It team, involving researchers in the Department of Chemistry, in collaboration with the Department of Chemical Engineering, Department of Electrical and Computer Engineering, and the Amy Facility for Chemical Instrumentation, had established a high-throughput experimental system that can screen over 3000 reactions per hour to evaluate how each reaction has proceeded. With the aid of the system, our team systematically studied the phenomenon to see if the glass effect is general, by testing dozens of reactions in contact with glass surfaces compared to the same reactions in the absence of glass. The broad applicability of solid(glass)/solution interfaces to multiple types of reactions was

demonstrated by measuring acceleration in reaction rates of 30 to 2000 times while non-recyclable bases are usually required to rev up such reactions.

More importantly, thorough mechanistic characterization of the role of glass surfaces was achieved. Glass particles were found to act as 'green' catalysts that can be easily reused after simple rinsing. The data generated by high-throughput experiments also broadened the scope of glass' effects on chemical reactions. They showed that the chemical groups on glass surfaces not only affect base-catalyzed chemical reactions but also act as strong bases that can turn solvent molecules, such as water, into powerful anions, which can further affect additional types of reactions. Some of these reactions indicate that vital biomolecules such as peptides and lipids, building blocks of cell membranes, can be degraded when stored in solutions inside glass containers.

The finding that biomolecules can undergo significant amounts of chemical degradation when in contact with glass surfaces raises awareness of the significance of the phenomenon in our daily lives. Considering the importance of lipids in many practical aspects of chemistry, including COVID-19 vaccines, another, perhaps even more important, observation made in my graduate research is that important biomolecules such as lipids, especially at low concentrations, can be chemically degraded by glass surfaces, despite glass containers being the current recommended method of storage. This research suggests the need for current advances in glass manufacturing to create new forms of glass that can safely store drug products and other chemical compounds. With this new understanding of chemistry at glass surfaces, the storage of biomolecules in glass containers should be avoided considering that many are unstable in bases. Also, the fact that glass surfaces could chemically degrade biomolecules should be considered in clinical settings.

My research expands the understanding of the role of solid/solution interfaces in reaction acceleration with implications for chemical synthesis and for the degradation of biomolecules. It underlines the fact that even a common material like glass is quite poorly understood. This study should bring interest to a broad scientific community because of the ubiquitous use of glassware in laboratories, the extensive effects of glass on various reaction types, the sustainability aspect of using glass as a 'green' catalyst, and the implications of the degradation effects for lipids used in bioanalytical studies and in clinical settings.

Find more details about this research at the following locations:

• Y. Li, T. F. Mehari, Z. Wei, Y. Liu and R. G. Cooks, Angew. Chem., Int. Ed., 2021, 60, 2929 —2933 (Angew. Chem., 2021, 133, 2965 —2969) https://onlinelibrary.wiley.com/doi/full/10.1002/anie.202014613

• Y. Li,‡ K.-H. Huang,‡ N. M. Morato and R. G. Cooks, Chem. Sci., 2021, 12, 9816-9822 https://pubs.rsc.org/en/content/articlelanding/2021/SC/D1SC02708E

• Visual aid: figure modified from "Y. Li, T. F. Mehari, Z. Wei, Y. Liu and R. G. Cooks, Angew. Chem., Int. Ed., 2021, 60, 2929 —2933 (Angew. Chem., 2021, 133, 2965 —2969)"

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YANGJIE LI

Yangjie Li earned a B.S. in Chemistry with Excellent Graduation Thesis Award from Beijing Normal University in 2016. She was a Ph.D. Candidate in the Division of Analytical Chemistry at Purdue University and a recipient of Henry Bohn Hass Memorial Fellowship as well as Thomas W. Keough Graduate Scholarship at the time of this submission. Yangjie Li's graduate research in Aston Labs for Mass Spectrometry under the supervision of Professor R. Graham Cooks was highlighted by Purdue News, C&EN and Chemistry World. After contributing to multiple research projects focusing on reaction acceleration at interfaces studied by mass spectrometry, Yangjie graduated in Summer 2021 and is now a postdoctoral research fellow at Zarelab in Stanford University, continuously contributing to the rising area of droplet chemistry.

BOILERS WORK

INTERNSHIP PROGRAM

The Boilers Work internship program provides ten graduate students per year with a $4,000 stipend to pursue an unpaid summer internship. This program is intended to help our students garner real-world work experience, refine soft-skills, and establish career connections prior to graduation. Below are the experiences of two Boilers Work interns.

DANIEL W. OESTERLE

Preventing sexual violence is an issue that impacts me both personally and professionally, and I have focused my career on addressing this issue since 2013. As a college student, many of us are intimately familiar with the prevalence of this public issue, where upwards of 25% of college women experience sexual assault during their time in college (Fedina et al., 2018). Although much work has been done to understand the prevalence, etiology, mental health outcomes, and prevention and response strategies for campus-based sexual assault, far less work has been done to understand this phenomenon among other populations. Through Purdue University's Boilers Work Program, I was able to serve as a Scientific Writing Intern with Dr. Lindsay Orchowski at the Alpert Medical School of Brown University, who spearheads several large, federally-funded sexual assault prevention programs among diverse communities. Throughout, I will highlight how I was able to contribute to furthering the scientific knowledge of intimate partner aggression and sexual violence in each of these communities.

Despite advancements that have been made in understanding sexual assault occurring on college campuses, various gaps in the literature still exist to best inform ongoing prevention programs and campus-based responses. As part of an intervention development study funded through the NIH National Institute of Alcoholism and Alcohol Abuse (NIAAA), Dr. Orchowski and her team have developed an integrated sexual assault and alcohol reduction program for heavy drinking college men. Given the extent to which alcohol consumption and sexual assault co-occur on college campuses, this study seeks to examine how well reducing alcohol use among a group at high risk for perpetrating

sexual assault actually works. As part of my internship, I was able to quantitatively analyze and co-lead a scientific paper on how men respond in dating and sexual situations when their partner indicates that they are no longer interested in pursuing sexual activity. Although most men in this study reported stopping the sexual activity, a small subset of men indicated their continued activity, despite their partner's wishes. These findings may help us identify and understand who might be at greatest risk for perpetrating sexual aggression, and in what specific contexts this is most likely to occur.

This opportunity also allowed me to explore and further understand sexual assault among other populations. As a graduate student in clinical psychology, almost all my work focuses on quantitative statistical analyses. Interestingly, this opportunity provided a critical training opportunity where I was able to receive in-depth training on qualitative data analyses, a unique data analytic method I likely would not receive extensive training on during graduate school. In that regard, I was able to contribute to three scientific papers using qualitative methods. Alongside Dr. Orchowski's team working on a Department of Defense funded study of an innovative prevention program for military men, I was able to contribute to a paper on how heavy-drinking men in the military conceptualize sexual consent. Additionally, I also co-led a team of qualitative coders analyzing transcripts of military men's use and understanding of bystander intervention, a community-based approach to preventing sexual violence. Qualitative approaches used in this project were able to provide unique insights and understandings among how interventions might best tailor their content to best fit the needs of this population. As part of a community-based participatory research study by the Centers for Disease Control and Prevention to reduce sexual aggression and bullying among middle school students, I was able to qualitatively explore school stakeholders' perceptions of sexual violence and bullying. This experience illuminated the specificity to which you can tailor individualized and personalized interventions using interviews and qualitative analyses, something that would be much more difficult using quantitative methods.

In sum, this experience allowed me to contribute to research that is meaningful to me, both personally and professionally. Through the Boilers Work Internship Program, I was able to pursue an opportunity that I likely would not have been able to do if this funding was not available. Not only was I able to contribute to several innovative projects on preventing sexual aggression, while also helping to co-author several peer-reviewed scientific papers but was able to foster meaningful relationships I hope will continue to develop across my professional career. Finally, I expect that the knowledge gained during this internship will allow me to continue to develop my own program of research, where I hope to positively impact communities that are disproportionately impacted by sexual violence.

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Daniel W. Oesterle (he/him/his) is a Frederick N. Andrews Research Fellow and second-year clinical psychology doctoral student within the Department of Psychological Sciences at Purdue University. Daniel's work focuses on intimate partner aggression, specifically sexual assault, where he is interested in examining alcohol and substance use as a primary risk factor for violence.

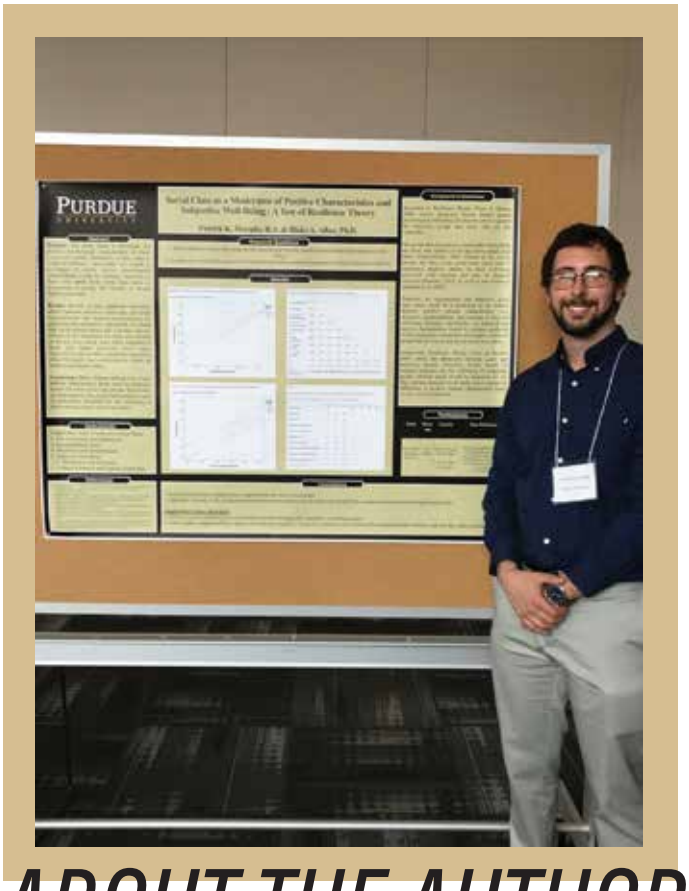
PATRICK MURPHY

Anxiety, depression, and other forms of mental distress are highly prevalent among youth in the United States. Yet, these concerns are even worse for youth in rural areas, as they experience high levels of mental disorder and suicide and have greater barriers to accessing mental health treatment. I have lived these problems firsthand. I was born and raised in rural Northern Indiana and witnessed my peers suffer the devastating effects of the drug epidemics and broader mental health crisis.

Shortly after I graduate high school, I decided to pursue a career as a psychologist to help address the problems that plagued my community. I worked diligently in college and eventually gained admission to the Ph.D. program in Counseling Psychology at Purdue. As part of our doctoral training, we complete three-year-long practica with local organizations to develop skills as health service providers. I jumped at the opportunity to work for Benton Central Jr./Sr. High School (BC) when it became available as a practicum site because it was close to home for me in many ways. I was confronted with a harsh reality within weeks of starting my practicum at BC—hundreds of students were struggling, and few were getting the treatment or support they needed. It became clear that I could have a greater impact if I helped the school address student mental health at a systems-level rather than only serving one student at a time. I worked with school leadership to expand my role and began consulting alongside my practicum work. And, thanks to the Boiler's Work Summer Internship Program, I was able to extend my consulting work past my practicum through the end of the summer.

In my role as a consultant, I aimed to help school leadership develop and implement school-wide programming. Collaboration was at the foundation of my work. Specifically, I recruited a group of teachers, principals, school counselors, librarians, and the school's resource officer and nurse to contribute to every step of the process. Through many emails and a few meetings, we identified past and current efforts to support student mental health, student needs, barriers to intervention, and possible solutions. As a result, the school implemented a mental health awareness week and raised $1,717 to support future programming and staff training. Additionally, I worked to develop a school climate survey to assess student mental health needs and supports. BC plans to use the data from the survey to further understand their students' needs, provide support, and apply for grants to fund additional counselors in the school.

Overall, I gained practical consulting experience and skills and gave back to my community. I also experienced how collaboration can transform and enhance consultation work. Moreover, this experience inspired me to use my training as a psychologist to address systemic problems and pursue work as an organizational consultant after graduation. Last, I feel both a sense of pride that I helped a community create lasting change and gratitude for the learning and relationships that I gained along the way.



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Patrick Murphy is a Ph.D. student in the Counseling Psychology program at Purdue. One of his primary career goals is to become an organizational consultant.

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[5] This table was created in Tableau using the following materials and is not adjusted for inflation. "Alumni Annual Giving Fund Contributors," Grove City College Bulletin: Alumni News, 65 no. 1, September 1979, 4-5. "Alumni Annual Giving Fund Contributors," Grove City College Bulletin: Alumni News, 66 no. 1, September 1980, 5. "Alumni Annual Giving Fund Contributors," Grove City College Bulletin: Alumni News, 67 no. 1 September 1981, 5. "Alumni Annual Giving Fund Contributors," Grove City College Bulletin: Alumni News, 68 no. 1, September 1982, 5. "Alumni Annual Giving Fund Contributors," Grove City College Bulletin: Alumni News, 73 no. 1, September 1987, 8. "Alumni Annual Giving Fund Contributors," Grove City College Bulletin: Alumni News, 74 no. 1, September 1988, 5. Each year includes all alumni and friends of the college. Discrepancy does exist in two of the years in one case of underreporting and overreporting the amount. This amount is not excessively large though. The sudden increase in 1986 comes from the willing of five estates to the college. However, a steady increase is viewed throughout the duration of the trial proceedings. These are from the holdings of the Grove City College Archives.

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