Letter from the Editor

Dear Reader,

Thank you for checking out the Spring 2020 issue of The Research Paper! Due to the disruptions caused by the COVID-19 pandemic this year, the magazine was unable to publish physical copies, and many executive board members, writers, and researchers were unable to continue with the magazine. Nevertheless, this issue is able to feature the stories of six amazing undergraduates at Cornell who have studied topics ranging from racial discrimination to microbiology. The events of 2020 have only underscored the crucial role of research in our society, and I hope this magazine will inspire others take part in this work to understand the world around us.

Sincerely,
Emily Yang

Acknowledgements:

The Research Paper is funded by the Student Activities Funding Commission. TRP would also like to thank our advisor, Dr. Laurel Southard, Director of Undergraduate Research, as well as all of the professors who helped promote the magazine.

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Battling Modern Racial Discrimination
Benjamin Fields by Madeline Hanscom

Benjamin Fields, Class of 2020, is an average Cornell University student. He likes to play Call of Duty, run sprints for the Track & Field team, and is a part of Black Students United at Cornell. Fields has also been the target of isolated events of overt racism.

In Oklahoma, Fields has lived with three generations of African American individuals and saw firsthand the pain and struggles that they went through. Moving forward, he hopes to “[make] my ancestors proud through taking advantage of educational opportunities to spread our stories and ways of thinking,” using his success to advance Pan African improvement since the “plight of black people is not just a national issue, but global.”

Upon coming to Cornell University, Fields felt a different type of discrimination which lay below the surface, unrecognized by the general population. Instead of outright comments, he noticed things such as people looking at him differently as he walked about campus, or that, more often than not, he was the last person in his classes to find a group during group work.

Fields decided to prove those who discouraged him wrong, using his frustration to fuel his work. He says he realizes “that the civil rights battle is not over,” and plans to use “research as a platform to do the most that I can at Cornell to prove stereotypes wrong.” He chose to do the most he could with his time at Cornell with two majors, one in Development Sociology and one in Global Public Health, accompanied by eight various minors ranging from Biological Sciences to Public Service and beyond. In his words, if you are “special on paper... then they will like you later on.”

Given the new opportunities and connections he had at Cornell, Fields decided to combat racial discrimination simply by shedding more light on the problem. When first starting with his research project, Fields reached out to people at all levels, from administrators to students, whom he thought could help effectively spread his survey and get him the representative sample he needed. Unfortunately, he found that most had “political” reasons not to help him. This led him to reach out to Dr. Hirschl, his current advisor, who gave him the best representative sample he could—Dr. Hirschl’s introductory development sociology class.

While researching for his senior thesis, Fields looked at how the kind of racial discrimination he personally experienced at Cornell University affected other Cornell students. He surveyed 250 students in the sociology class to see whether they felt like they were seen positively or negatively by others if they wore things commonly associated with their racial background. The results? It was ten times more likely that people thought they were being seen negatively.

It was through these findings that Fields was able to concoct a hypothesis: when one knows he or she is being labeled, a “double consciousness” begins to develop. This means that people may feel comfortable acting a certain way in a community where they do not think they are being labeled versus one where they do.

Fields noted that this is a linear progression: labeling changes one’s self perception and that altered self perception changes one’s actions. Ultimately, this means people are creating alternative identities (a double consciousness) depending on whether they think they are being labeled or not.

In developing this linear progression, Fields learned how to use and integrate theories to his advantage, rather than think of each theory independently. Additionally, he learned how important a proper representative sample is in the scientific community and how difficult that can be to achieve, especially as an undergraduate student.

Fields hopes in the future to get an even more representative sample and a greater quantity of participants to further support his hypothesis. While Fields was focused on racial discrimination in particular, he hopes to build off of his “double consciousness” idea in graduate school and apply it to people who feel they are labeled because of their obesity, to further shed light on the prejudices that still plague many today.
Erythritol: Even Sweeter Biomarker than Glucose?

Peyton Carpen by Emma Harte

First-year Biology & Society student Peyton Carpen hopes to pursue a MD-PhD degree in the future, but for now, she is focusing on developing the skills necessary to become a researcher through her work in Dr. Martha Field’s lab. Carpen works under Semira Ortiz, a PhD student in the Division of Nutritional Sciences, to study the activity of erythritol in the human body.

Erythritol, a sugar alcohol found in many fruits, is produced endogenously in humans and is often consumed as an artificial sweetener. Carpen and Ortiz expose lung cancer cells to erythritol to try to understand how the compound is absorbed and metabolized by humans. “Looking towards the future,” Carpen says, “we’re trying to see if [erythritol levels in the blood] could be a biomarker for various comorbidities like diabetes or heart disease.” If so, elevated erythritol could predict the development of diabetes years before glucose intolerance, one of the first known signs of the disease, is detected.

Carpen is hopeful that erythritol will prove to be an effective biomarker. She explains that high blood erythritol may reveal nascent problems with glucose tolerance before they are typically detected. In a healthy person, high blood sugar triggers the pancreas to release insulin, causing adipose cells to take up glucose from the bloodstream, reducing blood glucose levels. In a type II diabetic, however, adipose cells become resistant to insulin and blood glucose can increase dangerously. Physicians use this condition, known as glucose intolerance, to diagnose diabetes.

Scientists know that erythritol levels and disease are connected. In a study conducted at Cornell University beginning in fall 2011, researchers measured the height, weight, and blood erythritol of first-year students shortly after their arrival on campus and again at the end of the academic year. Students with higher initial blood erythritol gained more weight over the course of the study. Elevated erythritol levels are also associated with higher rates of diabetes later in life. Carpen and Ortiz hope this connection will eventually allow physicians to use erythritol as an early predictor of the disease.

Carpen began looking for a research position after taking BME 1110: Seeing Science in Action, a Learning Where You Live course taught by Professor Chris Schaffer. Through the course, Carpen shadowed a student in Professor Bethany Cummings’ lab in the Department of Biomedical Sciences. Schaffer and Cummings helped connect Carpen with Professor Martha Field, in whose lab Carpen currently works to study erythritol.

Carpen believes that her academic and extracurricular experiences have prepared her to conduct research. She has gained public speaking practice through participating in Speech and Debate competitions both at the high school and college level. As a Biology & Society major, she takes classes that develop communication abilities alongside her biology and chemistry courses. She points out that these skills are crucial for scientists, who spend hours reading journal articles and writing grant proposals. Carpen hopes that her work in the Field Lab will allow her to develop technical skills and learn more about research in nutrition. She explains, “It is such a cool feeling to be able to take what you’ve learned in the classroom and actually apply it.”

In addition to her love for lab work, Carpen is passionate about medicine. She hopes to become a physician to use “biology as a mechanism in order to help people.” To gain a deeper understanding of the issues that she will see in patients as a medical doctor, Carpen wants to pursue a PhD. She hopes that her work in the Field Lab will help prepare her for graduate school.

To undergraduates who want to get involved in research, Carpen suggests taking BME 1110 to explore different disciplines and connect with professors on campus. She encourages her peers to reach out to faculty members and find a lab that “meshes with [their] personality.” Carpen advises undergraduate researchers not to be discouraged if they are not initially working on an independent project. There is plenty to be gained from helping another lab member with their investigations, and, as Carpen explains, “The entire goal [of research] is just to learn.”
Using Quantum Physics to Make Machines Think
Andrew Yates by Sarah Berntson

Andrew Yates, who is a sophomore double majoring in Physics and Computer Science, loves the beauty of theoretical science and the satisfaction of solving problems. Luckily for Yates, there is a field of study that melds the theoretical, the practical, the beautiful, and the bizarre: quantum computing.

In Dr. Peter McMahon’s lab in the Applied and Engineering Physics department, Yates works with lasers, simulators, and classical computers. Most of his research time is spent outside the lab reading scientific literature, coding, problem solving, and drinking liters of coffee. He says the hardest part of his research is that “usually there’s no one else who knows the answer, so you have to rely on your teammates, you have to figure things out for yourself, you have to ask for help.” Cornell does not have a real quantum computer—yet—but in the meantime, McMahon’s lab uses IBM’s and Google’s machines via the Cloud. Although he was already a very proficient coder and regularly competes in hackathons, he found coding for a quantum system to be challenging because of the complicated differences between classical and quantum computers. Classical systems run on “Bits” which are either a one or a zero. Quantum systems run on “Qubits” which are made of photons that can have multiple identities between one and zero. The key thing that makes quantum computers faster and able to store more data is the “multiple identity” property of Qubits. This property is explained by quantum physics, a bizarre science based on four main ideas: entanglement, superposition, measurement, and interference.

These ideas are most famously described in the Double Slit experiment. This experiment shows that quantum particles are in a superposition of being both a particle and a wave, that quantum particles are able to interfere with each other similarly to how waves interfere, and that both of these quantum behaviors collapse when measured. “This is really freaky,” Yates says. Many physicists and computer scientists agree that harnessing the freakiness of quantum particles could lead to super-fast, super-powerful computers. This would be incredibly useful for Yates’ area of study: machine learning.

Lines of code can only teach a computer so much. For computers to “think” on their own something more powerful and complex is needed, something a bit more like the human brain. The solution is neural networks made by the process of machine learning. Machine learning is to code as natural selection is to organisms. Thousands of basic neural networks are tested and only the fittest (most accurate) survive. The fittest neural networks then “mutate” to form the next generation, then the fittest of that generation survive and mutate and so on. The end result is a neural network so complex that no human can decipher it, but somehow it works. Any test can be used to determine accuracy, for example identifying an object in a picture.

The speed and power of quantum computers could make large-scale machine learning a possibility. However, Yates says this is still a very young science, and that humanity is far from perfecting quantum computing. He is hopeful for the future applications of this science. “Physics is a very beautiful subject, especially quantum mechanics,” Yates says, “It’s amazing, and what I like the most is that I can apply something so amazing to a practical problem.” Most people interested in science are forced to work in either theoretical problems or practical problems, but Yates has found a niche where he can have the best of both. His post-sophomore year plans are to make a quantum computing club at Cornell, continue coding for fun with his friends, keep researching quantum computing, and eventually earn a PhD.
Club Sports and Cancer Research
Amrit Hingorani by Vincent Lam

No stranger to the laboratory, Amrit Hingorani has been conducting research since his days in high school. In the summer of 2015, he was an intern at the Albert Einstein College of Medicine, where he worked at a neuroscience laboratory. Currently, Hingorani is a senior in the College of Agriculture and Life Sciences majoring in the Biological and Nutritional Sciences. His love of the scientific process as well as his interest in the medical sciences were what motivated him to begin work in the lab of Dr. Richard A. Cerione at Cornell’s College of Veterinary Medicine.

Hingorani has been working on his honors thesis over the course of his senior year, and his research project focuses on the SIRT1 protein, which is involved in a variety of metabolic processes. SIRT1 is a deacetylase - a class of enzymes that increase the expression of specific genes. Previous studies conducted by the Cerione group revealed that downregulation of the protein is associated with greater aggression and migration of cancer cells, as well as faster aging in certain cells. Hingorani’s project is specifically concerned with elucidating pathways connecting the SIRT1 protein’s downregulation and the resulting phenotypes observed in cancer cells. To accomplish this, he carefully plans and carries out time-sensitive techniques such as Western Blotting, PCRs, and gel electrophoresis. He hopes that his and his team’s endeavors will help uncover potential therapeutic targets for certain cancers and provide a better understanding of how cancers can become so aggressive and metastatic. Such work may even reveal ways in which the process of aging can be slowed down in certain cells. This could bolster the vitality of organs such as the brain and heart, which have limited capacities to repair themselves.

In addition to the work that he performs at the Cerione lab, Hingorani conducts research on vascular systems in his hometown of Brooklyn, New York. These two sets of research endeavors have broadened his grasp on scientific inquiry, exposing him to both basic and clinical research. He is grateful for these experiences for allowing him to be “able to think in a different way and helping me see a new field I may potentially want to get into”. Such hands-on work has also helped prepare him for the rigorous work that awaits him in the MD-PhD programs he pursues. After he completes his undergraduate studies, Hingorani plans to travel the world, immersing himself in unfamiliar cultures and visiting various labs along the way. In doing so, he hopes to glean insight into new fields and enhance his ability to consider a range of different perspectives, a skill so vital in a life committed to scientific inquiry.

The laboratory struggles that typically discourage many fledgling researchers are the moments that Hingorani finds incredibly rewarding. In the earlier experiments that he conducted, mistakes abounded. Whether it’s orientating a gel incorrectly or using the wrong reagent, such mishaps can result in the loss of days of work. However large the setback, Hingorani has learned to take these errors in stride. He states that “You feel bad, but it’s always a learning opportunity if you take it as such.” These challenges represent the tumultuous journey every undergraduate researcher takes when making their first foray into lab work.

When he isn’t in the laboratory, you can expect to find him on a bed of fresh turf. Hingorani is a member of various athletic groups on campus, including Cornell’s club paintball and club field hockey teams, as well as Cornell’s club frisbee team, which he captains. Additionally, he is a member of the Alpha Zeta, Alpha Epsilon Delta, and Alpha Phi Omega fraternities.

Hingorani hopes that the joys of undergraduate research can be experienced by as many people as possible. Although life in the lab may not be for everyone, he encourages those with even a mild interest in doing research to look for opportunities available to them. If you’re looking to potentially stumble upon a new passion, “all it takes is an email.”
The Double Life of a Protein
Brianna Johnson by Ali Mazrui

The microbial community is a diverse one that plays a role in many aspects of life. It is truly fascinating how these organisms, despite being too small to interact with our senses, profoundly affect society both positively and negatively. For reasons ranging from the production of dairy products to the outbreak of pandemics that shake the world, it is no surprise that countless scientists are interested in learning more about how microorganisms tick.

For Brianna Johnson, a third-year undergraduate at Cornell University, this curiosity hits closer to home. Having suffered from several illnesses throughout her life, Johnson developed a fascination for the mechanisms that allow pathogens to replicate and the biological processes that enable her body to fight back. Naturally, she found herself in the lab of Tobias Dörr, a microbiology professor at Cornell, where she has been studying how bacterial cell walls maintain themselves and interact with antibiotics.

The inquiry that led to Johnson’s work began when Shannon Murphy, a graduate student in Dörr’s lab, found that a protein called AroK may play a role in certain cell wall regulatory functions of bacteria. The result was fascinating to the lab because, in scientific literature, the only well-known purpose of AroK is in its role as a part of a pathway for aromatic amino acid synthesis. It was not clear how these two processes could be related. Johnson took it upon herself to study this question further, and it became the foundation of her subsequent research.

One of the only mentions of AroK’s role in cell wall maintenance is a paper published in 1996, which found that deleting the aroK gene from the bacterium Escherichia coli increased the organism’s resistance to mecillinam, a cell wall-targeting antibiotic. Johnson was intrigued that such a significant effect was not studied more. Consequently, she made it her goal to “unearth the secondary function that no one had ever talked about and [that] could be salient in general cell wall maintenance and our understanding of antibiotics.” A 1996 paper only discussed how aroK affects E. coli, so her first step was to investigate its effect on another bacterium, Vibrio cholerae.

E. coli and V. cholerae are similar organisms in that their cell walls react similarly to antibiotics. Consequently, Johnson predicted that aroK would have the same effect on both bacteria. However, deleting the aroK gene from V. cholerae decreased resistance to mecillinam, the opposite of what occurred in 1996 with E. coli.

To investigate this effect further, Johnson wanted to see if the E. coli aroK gene could complement V. cholerae by taking the gene out of the former organism and putting it into the latter. When doing so, she saw that the gene behaved identically to the native one. Surprisingly, E. coli’s aroK was complementary to V. cholerae, even though the protein behaves differently in each organism. As part of her further research, Johnson wants to learn more about the mechanisms behind AroK’s interaction with the cell wall to help explain why the protein has two different pathways in similar bacteria.

An essential part of studying AroK’s secondary function involved looking for a connection with the protein’s more well-known behavior. Johnson figured that she could find such an association by giving genes to V. cholerae that produce similar proteins. Interestingly, these proteins did not interact with the cell wall, suggesting that these two functions of AroK are separate. Johnson realized the protein could undergo protein moonlighting or the act of fulfilling more than one task. She believes that the versatility of proteins is useful and under-acknowledged in biological research.

Johnson’s work has allowed her to present her research at the Cornell Institute of Host-Microbe Interactions and Disease symposium. She describes this event as a highlight of her research experience as she was able to receive feedback from many members of the scientific community. Additionally, she is grateful that her research gave her the skills needed to do real science. She states that “[the group] gave me a home in my lab even though I knew nothing coming in, and I’ve learned so much consequently… it has definitely been the cornerstone of my undergraduate career.”
OH SNAP! - Optimization of glycoSNAP for O-linked glycoproteins
Jody Mohammed by Amrit Hingorani

Cancer is the second leading cause of death worldwide, accounting for one out of every six deaths. As a result, a great deal of resources have poured in to support researchers who are working to combat this deadly disease. One such remarkable researcher is Jody Mohammed, a senior in chemical engineering with a particular interest in infectious disease biology. Mohammed always knew she wanted to experiment with research, and she was able to get her first wet lab experience in the lab of Matthew DeLisa, a Professor of Chemical and Biomolecular Engineering and the director of the Cornell Institute of Biotechnology. Mohammed joined the glycoprotein engineering group at the end of her sophomore year and started working in the lab immediately during the following summer. The glycoproteins the lab works on are human tumor-related biostructures used in studying cancer cell proliferation and communication. They are not normally found in bacterial cells, but scientific advancements in recent years have allowed researchers to use bacterial cells, such as E. coli, as hosts to produce such glycoproteins for further study. This is critical because it is much easier to study biostructures in a bacterial host as they are more stable and better able to replicate.

During Mohammed’s first year in the DeLisa lab, she helped with protocols and her mentor’s experiments as she focused on learning as much as she could in that time. While she was doing research full-time for four credits, she recounts that she was especially dedicated to her lab work and was in lab all the time, going above and beyond her credit requirements. Midway through her junior year, a new project was brought up, and she volunteered to spearhead it. The new project involved glycoSNAP, a high throughput screening assay that had been previously used for N-linked glycosylated proteins. The normal screening method to detect such proteins though western blotting and gel electrophoresis is more time consuming than the quick glycoSNAP protocol that yields a readout after just two days. Her mentor’s project involved O-linked glycoproteins, and thus, Mohammed’s job was to take the quicker protocol that worked for N-linked glycoproteins and tweak it to work with O-linked glycoproteins instead. This turned out to be very complicated because O-linked glycoproteins are much more sensitive to the conditions they are incubated and expressed in. As such, it took her a couple of months of trial and error, testing different temperatures, incubation lengths, and concentrations. She dedicated the summer after junior year to “get down and dirty with the work” in order to make significant headway on the project. With her hard work and perseverance, she was able to get some good data and showed that O-linked glycoproteins are expressible through glycoSNAP. During the fall of her senior year, Mohammed worked to finish up her summer work and was able to present her findings at a conference in Orlando!

Mohammed says her favorite parts of research have been learning the lab techniques that she plans to use in the future, meeting people with the same interests as her, and the feeling she experienced when her trials finally worked. On the other hand, her least favorite part of research was the trial and error part of it as she spent over two full months repeatedly running her experiment with different protocols in order to find the optimal conditions.

When it comes to advice for other undergraduate students interested in research, she says the most important thing is to be patient and ride the learning curve that comes with it. Mohammed says that a textbook or course can never teach fully the protocols and techniques learned in a wet lab as the hands-on experience allows one to find their “own way of doing things - their personal and unique style of
research and work.” She learned from the high learning curve in her field that you can’t become a successful researcher in a day, week, or month. The hard work and effort paid off for Mohammed, who loved her lab experience and is looking forward to being a co-author on an upcoming manuscript.

Mohammed’s future plans include graduate school in Canada or Europe followed by a career in application-based and hands-on research. After a decade or two of research, she hopes to one day work at the WHO or CDC still in the more technical science side of things. Inspired by her mentors who have guided her and supported her a great deal, she looks forward to paying that forward and mentoring others down the road.