5th Annual

ADVANCED SCIENCE RESEARCH SYMPOSIUM

May 22, 2024

Logo designed by ASR students and made by Stephanie Wang, ASR class of '23

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Message from ASR Seniors

There are 36 students in ASR.

While we all have varied interests in STEM and beyond, we are linked by our relentless drive for knowledge. We devote countless hours toiling over our projects.

Beginning as wide-eyed sophomores crafting our first science paper, the review article, then creating our own research project as juniors, and finally perfecting our presentations as seniors, we are all joined by our dedication to studying the unknown.

We challenge ourselves to push boundaries and ensure our project is the best it can be. Our research isn't simply a homework assignment; it displays the depths we are willing to go to satisfy our passions. Our passion guides us through hardships and gives us the resilience to step out of our comfort zones.

But we aren't alone in this journey. We are with our fellow ASR comrades who share similar experiences, for better or worse. It is not 'my' or 'their' research; it is a shared endeavor we were happy to embark on together.

ASR has shown us that achievements sprout from collaboration and shared love for discovery, and we are so excited to share our passions with you.

ASR Class of 2024

Message From Dr. Donohue

Dear Friends of the Columbia Prep ASR Program,

It is my honor tonight to join all of the friends of advanced science research to recognize the students who have taken on the challenges of the Advanced Science Research Program and especially to celebrate the seniors whose achievements we are so proud of!

When I inaugurated the ASR program at Columbia Prep, we had great hopes that it would inspire a new generation of scientific researchers at our School. I am delighted to report that after five years, the program has not only endured, it has ignited the passion of so many Prep School students. The vision was clear to the School's leaders, first Ms. Dean and Ms. Buckley and now Dr. Wilson. We had a talented teacher in Mr. Yashin who was willing to take the risk of stepping outside the "teacher as content expert" box. We had an accomplished and confident Science Department providing a foundation for the new program, and we had a strong academic program in place in the Middle and Prep School divisions, ensuring that students were well prepared in the research, math and writing skills that are required to be successful in the ASR program. Without all of these pieces in place, we would not be here today.

Then, there is the most crucial part of the equation – our students! There is no doubt that our Prep School students have the zest for creative, authentic and challenging experiences. They have the intellectual and personal qualities required to withstand the ups and downs that accompany a three year academic adventure, and the reality of a little competition only sweetens the deal!

Thank you seniors, not only for your achievements, but also for your leadership and role modeling for the ASR sophomores and juniors. Finally, seniors, thank you for your support of each other. You have proven that you can be both competitors and companions – that is an essential lesson for our times. Our futures are bright because of you – congratulations to all!

Sincerely,

Dr. Bill Donohue,
Head of School

Congratulations to the ASR Class of 2024!

MEET THE CLASS OF 2024!

Phoebe Cohen

The Impact of Cyclone Pam on Birth Weight in Vanuatu

Mentor: Dr. Kelsey Dancause, *McGill University*

There are 32 million low-birth-weight (LBW) infants born globally every year, and 96% of those LBW infants occur in lower-middle-income countries (LMICs). One factor that affects LBW outcomes is environmental disasters. My study focuses on cyclone Pam, a category 5 cyclone that hit Vanuatu, a small LMIC in the South Pacific, in March 2015 since we know tropical cyclones increase the odds of LBW. Although the connection between natural disasters and increased risk of LBW is established, there is a lack of research conducted in LMIC. To address this gap, I studied the birth records before, during, and after the environmental exposure to Cyclone Pam in Vanuatu.

I calculated the mean birth weight (BW) by trimester of exposure to cyclone Pam to determine the overall trend of BW from 2009 to 2016. I included the years before and after cyclone Pam to take into account the natural variations in BW by year. Unexpectedly, the BW increased in Vanuatu from 2009 to 2016. I used linear regression to confirm the general trend. I found the same increase in BW when comparing pregnant mothers exposed to cyclone Pam in trimester one to mothers exposed to cyclone Pam in preconception. The upward trend in BW exemplifies a general increase in maternal care in Vanuatu. This finding is especially important as Vanuatu's location is particularly vulnerable to natural disasters, which are expected to increase in severity and frequency due to climate change.

To try to explain this pattern, I analyzed maternal hemoglobin levels (Hb) before, during, and after cyclone Pam, as moderate levels of Hb had been found to indicate a healthy and increasing BW trend. There were no significant differences in maternal Hb levels during, before, and after cyclone Pam when compared to the same months several years earlier. Given that my research cannot connect increasing BW with Hb levels during cyclone Pam, future research should analyze if maternal Hb is affected by natural disasters and if maternal Hb affects BW outcomes.

This study provides hope for other LMICs that it's possible to improve prenatal care and overcome the risk of LBW when faced with severe natural disasters.

- Entrant, *Regeneron Science Talent Search* '24
- Entrant, *New York-Metro Junior Science and Humanities Symposium* '24
- Entrant, *Terra* NYC STEM *Fair* '24

COLLEGE: Georgetown University
INTENDED MAJOR: Public Policy

What inspired you to choose this topic?

Growing up in NYC, I've always cherished the greenery around me, from Central Park to Riverside. My appreciation of the environment grew, and I began participating in local climate change marches. I've also always felt passionate about women's issues I read in the news and saw on TV. This broad love for the Earth and women's issues led to the narrower field of disproportionate impact of environmental exposures on pregnant women and their newborns.

What influence did the older ASR classmates have on you?

Older ASR classmates encouraged me to keep going when they knew I struggled with motivation and had thoughts about dropping out. The upperclassmen in ASR fostered a community where I felt safe to ask for help or pose questions about anything from statistical analysis to presentations or just general life stuff.

What's a misconception that people have about ASR or ASR students?

When I was a freshman, the rumor about ASR was that you would have no life outside of school if you were in the program. I had a feeling that the gossip wasn't true, and I was determined to prove them wrong. I'm very happy to confidently state that you can have a fun and social life while succeeding in ASR. There is definitely a learning curve with time management, but that skill will come with time and making mistakes.

Most important thing you've learned in ASR?

Communicating tricky results. In ASR we practice presenting results in the form of slides and poster boards in addition to writing. The ability to communicate something complicated to any audience is a skill that is necessary for many jobs, and it has already helped me in school and at my internships.

Mia Grasso

Discovering the causal variants in dyslexia through combining genetic and neuroscience studies

Mentor: Dr. Gao Wang,
Columbia University

Dyslexia, which affects ~5-12% of English speakers, is a complex learning disability characterized by challenges in reading and interpreting words. Genetic and neuroimaging studies on dyslexia are inconsistent and likely have many false positives, impeding our understanding of the genetic mechanisms of dyslexia.

My research aims to address these challenges through a methodology that involves comparing genetic and neuroscience studies. The genetic study (GWAS) I use compares the genome of someone with dyslexia to those without dyslexia, resulting in a list of variants or errors in the genome that are associated with dyslexia. This GWAS dataset was run by 23andme and is the largest dyslexia genetic study to date. I used a neuroscience study provided to me by my mentor, which looks at the variants (differences in your genome) that have an effect on the brain. This is known as eQTL data. This choice was based on the premise that variants that are expressed in the brain (and observable in the brain via a brain scan) contribute to the behavioral presentation of dyslexia. To ensure the appropriateness of eQTL data, I compared different types of brain data with the dyslexia dataset that I received through 23andme by emailing the authors and identifying the most shared variants between the eQTL and GWAS datasets.

The outcomes of my study unveiled chromosome 9 as a previously undiscovered region associated with dyslexia. Importantly, the regions I identified (on chromosome 9) also impact the cerebellar hemisphere, which is thought to be one of the underlying causes of reading difficulties and learning disabilities like dyslexia. It's worth noting that despite some dyslexia genetic studies pointing to variants on chromosome 9, they had not achieved statistical significance.

- Semifinalist, *New York-Metro Junior Science and Humanities Symposium* '24
- 1st place in Neuroscience, *Terra* NYC STEM *Fair Finals* '24
- Entrant, *Regeneron Science Talent Search* '24

COLLEGE: Cornell University
INTENDED MAJOR: Human Development

Coolest part of your research project?

Going to Columbia University to work in a lab. I loved how I looked around and saw PhD's and graduate students working around me, even if they were working on different projects.

What's a misconception that people have about ASR or ASR students?

People believe that people in ASR are naturally good at science. This is far from the truth. We are good in many different areas, from English to history, but no one in this class is a genius or anything.

Most important thing you've learned in ASR?

The most important thing I have learned in ASR is time management and the importance of going out and getting what you want. Throughout ASR, you will have the opportunity to push your limits, and you should take each opportunity because as soon as you know it you will be a senior, and those opportunities will be gone.

What inspired you to choose this topic?

I was inspired to do a project on dyslexia because I have it. I have always dreamed of giving back to the dyslexia community, which eventually taught me how to read. I love how ASR allowed me to start researching dyslexia in high school.

Funny anecdote from ASR

Ciderman. Mr. Yashin dressed up for Halloween as Ciderman and gave us all hot cider to have during class. This allowed us to relax, connect, and ask any questions we had for Mr. Yashin that day.

Class of 2024

Mysha Javeri

The association of the traits of urban aquatic birds and their population genetic patterns

Mentor: Dr. Chloé Schmidt, *German Centre for Integrative Biodiversity Research*

As urban development expands, the conditions presented by cities play more of a role in the genetic structures of various species of animals and plants. For some species, cities can be beneficial; for example, pigeons are widespread in cities, and the habitat offered by cities fits their needs. However, for other species, urbanization can reduce their genetic diversity. This was made apparent in my mentor's study, which showed that for non-aquatic birds, urbanization benefited their population's genetic structures by increasing their genetic diversity, but the opposite was true for aquatic birds. To understand this disparity, I tested the hypothesis that traits more commonly associated with aquatic birds impacted the relationship between urbanization and genetic diversity.

I used a publicly available dataset on bird traits and tested the effect of 13 different traits. Surprisingly, I found that none of them had an association with the population-genetic patterns. While further testing may be needed to completely rule out this hypothesis, it may also be true that other factors, such as water pollution in urban spaces, may be a more viable explanation for this disparity.

- Entrant, *Regeneron Science Talent Search* '24
- Entrant, *New York-Metro Junior Science and Humanities Symposium* '24
- Entrant, *Terra* NYC STEM *Fair* '24

COLLEGE: University of Michigan
INTENDED MAJOR: Undecided

Class of 2024

Maya Kazemi

Validating a liquid culture as a control group for 2D and 3D leukemia cell models

Mentors: Dr. Monica Guzman and Dr. Leandro Martinez, *Weill Cornell Medicine*

Leukemia is characterized by the expansion of abnormal blood cells in the bone marrow and blood. Leukemia cells are surrounded and altered by their microenvironment, which protects and provides a sanctuary to them. This helps them evade common treatment options such as chemotherapy, which can ultimately lead to relapse for many patients. The goal of my study was to validate the use of a liquid culture as a reference point for a new 3D model that my mentor and his lab are developing and using to evaluate different leukemia cell lines in the context of their microenvironment.

After analyzing the number of cells present in the liquid culture with a Cell Countess machine in the lab, I found that the number of cells increased each day, showing that the cells were not proliferating at a reduced rate and behaved as expected. In addition, at the end of the three days, there were more leukemia cells present in the liquid culture compared to the 2D and 3D cultures, meaning that cells in the liquid culture proliferated at a higher rate than cells in the other models.

My project validated the use of a liquid control as a control group for 2D and 3D leukemia cell models and showed certain advantages to using the 3D model. With a valid control and confirmation that certain newer models are better able to replicate the bone marrow microenvironment, more studies should investigate 3D models and their characteristics for evaluating leukemia to eventually be able to study the interactions between leukemia cells and their bone marrow microenvironment in 3D, potentially with the addition of treatment.

- Semifinalist, *New York-Metro Junior Science and Humanities Symposium '24*
- Entrant, *Terra NYC STEM Fair '24*
- Entrant, *Regeneron Science Talent Search '24*

COLLEGE: University of Toronto
INTENDED MAJOR: Global Health

Most satisfying part of your research project?

Working in the lab over the summer and being able to talk about my research in a lab meeting. It was cool as a high school student to be able to work alongside researchers and get to join in on lab meetings. When everyone would go around the table and discuss what they were working on, I got to be a part of that and share my progress and answer questions about my work.

What were some of your fears and worries when you applied to ASR?

At first, I was definitely worried about being able to handle the amount of work that ASR requires and was intimidated by all the things students in ASR were doing or have done. It all seemed daunting. To younger students who have those same fears, I would say that taking the chance and trying it out was so worth it, and I am so glad that I did and stuck with it. There is so much support within ASR, which all comes together to help you succeed with the workload and time management and really be able to individualize your experience so that you get what you want out of it.

Proudest accomplishment in ASR?

I think that all the smaller steps along the way have come together to form what I am proud of in ASR, like writing my review article, finding a mentor, finishing my project and paper, and finally, having the opportunity to present my research alongside other students in NYC. All these milestones have had their own challenges and have taken a lot of work, and I am proud of the way that I completed them and the way that they have all built upon each other.

Most important thing you've learned in ASR?

Through ASR, I have learned how to be more independent in my academics. One thing in particular that has stuck with me from ASR has been problem-solving and always coming up with potential solutions or answers to questions before relying on others for an answer. This independence has also carried into being more comfortable with emails and in professional situations. Additionally, the presentation skills I have gained from ASR have helped me so much in other academic areas, and I believe they will stick with me throughout my academic career.

Class of 2024

Mira Lengsfield

Identifying mechanisms of lysosomal cross-correction in MPSIIIC by gene-modified hematopoietic stem and progenitor cells

Mentors: Dr. Stephanie Cherqui and Dr. Rafael Badell-Grau,
University of California San Diego

Mucopolysaccharidosis type IIIC (MPSIIIC) is a severe neurological disorder that affects the lysosomal enzyme HGSNAT and impacts its ability to break down a complex sugar molecule called heparan sulfate. To treat this disease, my mentor proposed using a gene-modified stem cell therapy. They found that the treatment effectively reduces the accumulation of heparan sulfate within cells, suggesting healthy enzymes are being transferred from stem cells to diseased cells, allowing for heparan sulfate breakdown. However, they did not know how this process was occurring. My goal was to investigate how healthy copies of the HGSNAT enzyme are transferred to disease cells. Specifically, I wanted to investigate the role of tunneling nanotubes (TNTs), which are tiny tube-like structures that form between cells.

At my mentor's lab, I set up cell cultures with diseased and healthy stem-cell-derived cells to observe their interactions and mechanisms of enzyme transfer. Once I set up cocultures, I used time-lapse imaging to observe the subsequent cellular communication.

I found that TNTs enabled HGSNAT transfer from healthy to enzyme-deficient diseased cells. Additionally, I identified the fusion of healthy and diseased lysosomes within diseased cells as a means of alleviating sugar buildup. This is the first report of TNT-mediated transfer of healthy enzymes to diseased cells in the context of a neurodegenerative disease after this kind of stem cell treatment.

These results overall contribute to the understanding of HSPC treatment and the possibility of FDA approval of this treatment for human patients, which requires some understanding of the mechanism.

- Finalist, *New York-Metro Junior Science and Humanities Symposium* '24 (1st place in Biomedical Sciences at *Semifinals*)
- Entrant, *Regeneron Science Talent Search* '24
- Entrant, *Terra* NYC STEM *Fair* '23

COLLEGE: Georgetown University
INTENDED MAJOR: Human Science

Most satisfying part of your research project?

It's the deep knowledge I have acquired on a subject I am truly passionate about. It's a feeling like no other. Conducting research on a topic that I am interested in, rather than simply working for a grade, is incredibly rewarding. The hours I spent working on this project are so worth it, justified by the opportunity to explore a subject that genuinely matters to me. Presenting on such a niche topic to my peers and sharing my knowledge brings a tremendous sense of fulfillment in my life.

What were some of your fears and worries when you applied to ASR?

As someone who plays three sports, takes a ton of other classes, and has many outside-of-school hobbies, I worried that I wouldn't have enough time for it all. But I quickly realized that it is possible to take ASR and have relatively the same life I did before! I learned super important time-management skills that I will carry with me for the rest of my life. Even if you struggle to manage your time, your peers and Mr. Yashin will be there to help you!

What's a misconception that people have about ASR or ASR students?

It's that science consists of one person working in a lab by themselves. After almost three years of ASR, I have learned that science is a field of collaboration. When I first walked into my first ASR class, I felt out of place and alone and thought that this was a journey that I would embark on independently. But I soon realized that me and the other students in my class were in it together. It was no longer 'my' or 'their' research; it became a shared endeavor. My classmates and I spent countless hours working together, editing each other's papers and practicing presenting. These experiences have shown me that achievements sprout from collective collaboration.

Most important thing you've learned in ASR?

I've learned to embrace the challenges in this class. Writing a comprehensive review article for the first time is tough. Reaching out to professors in a field where I have limited knowledge is no easy feat. Conducting a research project and writing a college-level research paper is daunting at first. However, this class has instilled in me the understanding that overcoming these challenges is not only a positive experience but a privilege. Struggling with something you're passionate about and then persevering to create something exceptional is so rewarding. The difficulty of these tasks is immensely justified. Beyond gaining valuable research experience and gaining skills like paper-writing, editing, and presenting, this class gives you a profound sense of determination and perseverance that will stay with you throughout your life.

E. Grey Linsley

Foraminiferal organic linings at a Hudson River Estuary: Linked with rubidium, manganese, high concentrations of pyrite, and linked to other foraminifera species, T. inflata

Mentor: Dr. Logan Brenner, *Barnard College*

I investigated Golden Foraminiferal Organic Linings (GFOLs) from the Hudson River Estuary at Piermont Pier in Piermont, NY. Foraminifera are single-celled microorganisms that have an outer test (shell) that rarely becomes separated from the inner organic lining (GFOL), which is essentially a smaller internal shell. Foraminifera are extremely sensitive to changes in temperature, salinity, acidity, dissolved oxygen, nutrients, etc., which can control species richness and abundance at a given site. Foraminifera can be used to study environmental parameters and are an instrumental tool for the reconstruction of environmental conditions and monitoring the health of an ecosystem. There is a lack of a GFOL database as foraminifera are primarily speciated by their test morphology, and separated GFOLs lack their tests. Specific environmental conditions that lead to the preservation of GFOLs are also unknown.

My research goal was to identify them at the genus level and understand the environmental conditions related to their abundance and preservation. I collected data in three primary ways: (a) by assessing the amount of organic matter in a sample by weighing sediment samples before and after incineration to measure how much organic matter had burned off; (b) by using X-ray fluorescence to analyze the elements present within the sediment; and (c) by counting and identifying the abundances of the six species of foraminifera that my mentor's lab was looking for, along with counting and identifying the GFOLs, all of which I did by examining the samples under a microscope.

I found that (1) counts of GFOLs and the foraminifera species *T. inflata* are correlated with the amount of organic matter in a sample; (2) T. inflata and GFOLs counts are correlated with each other; (3) Two *T. inflata* specimens from all picked foraminifera contained visible GFOLs in the center of their spiral. GFOL counts were correlated with metals manganese and rubidium, both indicators of human pollution.

These three converging pieces of evidence suggest that the GFOLs found are the GFOLs of *T. inflata* that had lost their tests due to high amounts of organic matter, manganese, and rubidium.

- Finalist, *New York-Metro Junior Science and Humanities Symposium* '24 (1st place in Environmental Science at *Semifinals*)
- Entrant, *Regeneron Science Talent Search* '24
- Entrant, *Terra* NYC STEM *Fair* '24

COLLEGE: Barnard College
INTENDED MAJOR: Business Management and Art History

Most satisfying part of your research project?

Picking foraminifera. Every time I would finish a tray and carefully transfer it into the "completed" vial, it would just make me smile. Not to mention that foraminifera are beautiful: getting to look at them all day under a microscope and see all the vibrant colors of the sediment, and see the golden sheen of the GFOLs, and the glittery tests of the other foraminifera was just so awesome. Sometimes I would close my eyes to go to sleep at night and see foraminifera swimming about, just because they became such an important part of my life for a few weeks. All my time spent in the lab was deeply formative for who I am as a scientist today and was an incredible experience to have had. I am deeply thankful for all that my mentor has helped me with.

What influence did the older ASR classmates have on you?

The older kids have the biggest influence on you when you're a sophomore. I remember being in awe of how skilled and hardworking other people were. It's easy to forget that skill comes with practice and most importantly helpful advice from people who have done this before you. I have been lucky enough to know some of the hardest-working people I have ever met in my life through ASR, who have helped me grow as a scientist, as a researcher, as a friend, and as a person. The seniors this year have all been trying to help the sophomores and the juniors as best as we can by trying to supply all the helpful advice we have received during our time in ASR. ASR is very much an intertwined community, which is a huge part of the reason so much incredible research can happen.

What were some of your fears and worries when you applied to ASR?

As a freshman, I was more of a humanities person, and I was worried that I wasn't sciencey enough for ASR, but I have proven myself so wrong over these past three years. ASR is as much about how to provide helpful feedback and how to write a well-thought-out paper as it is about science. ASR essentially becomes whatever you want to be, granting you the ability to study anything from music to textiles.

Michael Shor

Fast and efficient ion transport in a trapped-ion quantum computer through low-pass filter design

Mentor: Dr. Daniel Slichter, *National Institute of Standards and Technology*

The field of quantum computing is the application of quantum physics to create a computer that is faster and more efficient than any other computer. A trapped-ion quantum computer is a type of quantum computer that uses trapped ions as the base piece of information known as a qubit. Bits and qubits are the basic units of structure underlying all computers. Performing operations with multiple qubits can be successful only if the individual ions are moved around in the trap efficiently in order to keep the information that the ions hold intact. The problem is that electronic signals that are meant to move the ion within the trap often contain the kind of noise that can eject the ion out of the trap. This noise needs to be filtered out.

To achieve this, I designed six different filters and then simulated those six different filters based on two different types of signals: triangle and ion transport. The triangle signals were used to assess the general structure of each filter, and the ion transport signals were used to determine which of the filters would be the best fit for the ion trap. I used a program called LTspice to simulate the filters and imported the data for both simulations into Mathematica. I analyzed the data based on how much motion the ion gained throughout the transport process, which involves moving both the ion and the signal that traps it from one location to another. One key example of ion transport is moving the ion from its initial load location in the trap to the experiment zone, where quantum computations are performed on the ion. The simulations were also performed on a range of transport durations to assess the effects at a fast transport time.

I found that the Butterworth 5-pole is the best filter for triangle signals, and the Bessel 3-pole is the best for fast ion transport. The implementation of the most successful low-pass filter from the second set of tests in the ion trap system will result in a general improvement in the transport operation in a trapped ion quantum computer. This improvement in transport will subsequently improve the overall performance of the quantum computer when performing operations with multiple pieces of information (i.e., multiple ions).

- 2nd place in Physical Sciences, *New York-Metro Junior Science and Humanities Symposium Semifinals* '24
- 6th place, *New York-Metro Junior Science and Humanities Symposium Finals* '24
- 2nd place in Physics and Space, *Terra NYC STEM Fair Finals* '24
- Entrant, *Regeneron Science Talent Search* '24

COLLEGE: Carnegie Melon University
INTENDED MAJOR: Physics

Coolest and most difficult parts of your research project?

Coolest: Interning at my mentor's lab and witnessing the entire ion trap system and a real working quantum computer.

Most difficult: Designing the constrained optimization system in Mathematica coding language. Being able to utilize various complex functions to generate real signals that are sent to the quantum computer.

What were some of your fears and worries when you applied to ASR?

Completing a research project and finding a mentor in a complex field. ASR prepares you well to achieve both of these goals, and as long as you follow deadlines and directions, you will achieve them.

What's a misconception that people have about ASR, and what's the truth?

It's that the only type of project you can do is in physics, chemistry, or biology. In reality, there are many other topics that are not "hard science" that you can do a project on.

Class of 2024

Graham Smith

Performance prediction for future VTOL unmanned aerial vehicles using preliminary sizing models

Mentor: Andre Luiz Martins, *Gulfstream Aerospace*

Currently, Unmanned Aerial Vehicles (UAVs) are at a critical stage of development, where there are enough current UAV designs and predictions about future battery technology and its related performance that forecasts on future UAV performance can be made based on this public data. These forecasts are important because they could be used to optimize support infrastructure for UAVs used for package delivery. Previously, research on predicting electric performance had focused on larger, passenger-carrying, fixed-wing aircraft, and the results were not transferable to smaller UAVs. One reason that research hasn't focused on these smaller UAVs is a lack of data.

Therefore, I manually collected data online on 40 UAV designs as there was no dataset for the designs and specifications that I needed, which was used for training the design tool. Then, I came up with a very computationally simple way to create these forecasts, which was by creating a sizing model for electric UAVs. A sizing model is a method for estimating certain characteristics of a potential aircraft design, and it is usually the first step in the design process for any aerial vehicle. I developed the UAV sizing model by altering a common plane design tool to work with electric UAVs and use recent UAV data. I determined the accuracy of my UAV design tool by comparing it to items in my database and comparing it to a similar model for regular planes.

My tool was slightly less accurate than the comparable model, with an 18 percentage point higher error, which was considered a good result considering the lower amount of data relating to electric drones. I then varied the different battery technologies and inputted the assumed values into my tool to predict the future performance of drones. I showed the relationship between range, which is how far the UAV can travel, its total weight, and how much it can carry. In summary, I made a uniquely computationally simple and general UAV design tool.

- Semifinalist, *New York-Metro Junior Science and Humanities Symposium* '24
- Entrant, *Terra* NYC STEM *Fair* '24
- Entrant, *Regeneron Science Talent Search* '24

COLLEGE: Princeton University
INTENDED MAJOR: Aerospace Engineering

Most satisfying part of your research project?

In the middle of the summer before senior year, I had finished the first major project but had not talked to my mentor since my initial idea for the project. I was not sure if my project was actually "good" in the sense that my methods would produce meaningful results. So, I was incredibly nervous about my meeting with him. Once he understood my project, hearing him say that this was a great project was so satisfying and will always be a fond memory.

What inspired you to choose this topic?

When I was younger, I read the book The World's Greatest Aircraft, and since then, I've been obsessed with flight. Throughout my education, I have maintained my passion for planes, and when I was accepted to ASR, I wanted to study aeronautical engineering. I was working on a different project but realized that the methodology could instead be used for my current project, which was much more interesting to me. So, I pivoted and came up with the entire project with help from my mentor.

Most important thing you've learned in ASR?

To not be intimidated by intelligent people. When we come into the classroom as sophomores, some seniors do research at a master's level. A key part of the class is gaining the confidence that you can get to that level. Now that I have passed that hurdle, I realize that this skill allows someone to be more present than they would be if they were worried about not being smart enough for the person that they are talking to.

Gavin Ye

De novo drug design as GPT language modeling: Large chemistry models with supervised and reinforcement learning

Mentor: Dr. Gil Alterovitz,
Massachusetts Insitute of Technology and Harvard University

Drug discovery is one of the most time-consuming and costly aspects of developing drugs, one reason being the impossibility of testing all synthesizable molecules for potential effectiveness. Because molecules can be represented in “languages” that algorithms can interpret, it is possible to retool language processing machine learning (ML) models such as GPT models for drug design. Traditional non-large language models for drug design from previous studies often generate nonsensical (invalid) representations that do not represent actual molecules (like ChatGPT producing gibberish). Thus, my goal was to use GPT to design drug candidates that are both highly effective in targeting a specified drug target and chemically valid.

Before I could train a GPT model for generating effective molecules, I designed my own efficacy evaluation model to evaluate the drug effectiveness (a.k.a efficacy) of any molecule quickly, as it would be impractical to synthesize every machine-designed molecule throughout the training process. Then, I trained my GPT model to design similar drug-like molecules as candidates designed by humans from the dataset. Finally, I used my trained efficacy evaluation model to optimize my GPT model for designing higher efficacy molecules using reinforcement learning. I used the amyloid-precursor protein, a promising drug target for Alzheimer's disease, as a case study for using GPT for drug design. However, the same methodology can be applied to transfer my GPT model to target different proteins using different datasets.

My efficacy evaluation model is 2.3 times more accurate than the state-of-the-art models from earlier studies. Almost all (99.2%) of the designed molecules by my GPT model are highly effective. In addition, all of the designed molecules are still chemically valid and novel, as the designed molecules do not exist in the dataset. Future studies can take inspiration from OpenAI and have human chemists provide feedback directly to the GPT model. The GPT-designed drug candidate molecules exhibit properties similar to those from the dataset, and thus, future studies can leverage this phenomenon to make patented drugs accessible by generating similar ones. These implications from results and future research extensions have the potential to transform drug discovery.

- 1st place in Mathematics & Computer Science, *New York-Metro Junior Science and Humanities Symposium Semifinals '24*
- 5th place, NYC *JSHS Regional Finals*; part of the 5-person NYC delegation to the *62nd National JSHS*
- 1st place in Software & Robotics, *Terra NYC STEM Fair '24 Finals*; one of 13 projects from NYC to advance to ISEF Finals
- Single-author paper published in the peer-reviewed *Journal of Computer-Aided Molecular Design*

COLLEGE: Harvard University
INTENDED MAJOR: Computer Science

Most difficult part of your research project?

Designing and implementing the drug efficacy optimization process in a short period of time (in August, before school starts). My original idea was to preserve the differentiability of the designed molecules and pass. However, this was not possible as the efficacy evaluation model takes a different, combined representation that has a molecule's chemical property calculated; conversions between representations are not differentiable operations. In other words, I had to delete my old implementation mid-way through and re-implement a new one.

What influence did the older ASR classmates have on you?

During last year's symposium, Raihana (ASR class of '22) suggested trying to add explainability to the drug-synthesis model (my proposed methodology at the time was slightly different). Although I did not implement a drug-synthesis model in the end, I found a way to add explainability to the drug effectiveness evaluation model. To the best of my and my mentor's knowledge, this has never been done, especially for a neural network drug effectiveness evaluation model. (Thanks, Raihana!)

Last year, I spent a lot of time talking and creating manim (Python) math animations with Lucas (ASR class of '23). This inspired how I explain and present equations on my slides.

Funny anecdote from ASR

Being the first team to escape the escape room as we were trapped in a biology lab and Ms. Bertram, our biology teacher, was on our team. During the escape room game, Ms. Bertram was just teaching us what each tool is. "Here's the centrifuge! That's the incubator!!"

MEET THE CLASS OF 2025!!

Daniel Amoils

Testing General Relativity with the stellar-mass black hole in MAXI J1820+070 using X-ray reflection spectroscopy

Mentor: Dr. Cosimo Bambi,
Fudan University

General Relativity (GR) is our current best theory of gravity, but it is believed that the theory breaks down in extreme scenarios, such as inside a black hole. A black hole is the remnant of a star, a region of space where gravity is so strong that nothing, not even light, can escape. In GR, the space around a black hole is described by the Kerr metric. My project attempts to measure potential deviations from the Kerr metric around the black hole known as MAXI J1820+070 to test GR. These deviations are quantified using the α13 deformation parameter. When the value of this parameter is zero, the observation matches the prediction of the Kerr metric from GR, and when it doesn't equal zero, the prediction and observations differ.

To measure the deviations, I used the X-ray light emitted from the accretion disk, a disk of hot gas around the black hole. I used the models *nkbb* and *relxill_nk*, developed by my mentor, to constrain α13. *Nkbb* models the light emitted from the heat of the gas in the disk, and *relxill_nk* models the light that is reflected off of the disk. I selected two observations from the NuSTAR telescope and then extracted spectral data from the results. I then fit these spectra to *nkbb* and *relxill_nk* and found the parameters that best matched the data.

My results show that the constraints from one of the observations used were stronger than those in previous studies but did not agree with the value predicted by GR. This result was likely due to the models not being well suited to the observation rather than evidence against GR. The constraints from the other observation were not as strong due to there not being strong enough data to distinguish the value of the parameter. The strong constraints from one of the observations suggest that other observations from this black hole may provide both strong and accurate constraints.

Awards:

- 3rd place in Physical Sciences, *NYC JSHS Regional Semifinals '24*
- 3rd place in Physics and Space, *Terra NYC STEM Fair '24*

Mila Arbitman

Differences in gender equality across the US and variations in the gender gap among math top performers

Mentor: Dr. Erin Hennes,
University of Missouri

Research has shown that the gender gap in math test scores for pre-college students is largely due to the stereotypical role of women in the local culture. This effect has been measured across over 30 countries, with results showing a strong correlation between the level of gender equality measured by the Gender Equality Index (GEI) and the gender gap in math sections of standardized testing. However, the GEI was made to measure the gender equality of a range of European countries, and this study has not been replicated by looking at different regions in the United States.

Since the choice of what to study in college and what career to pursue is largely based on perceived aptitude and enjoyment of the subject based on the student's previous experiences, many mathematics majors and people in math-related fields tend to be previously high-achieving students in math and other STEM subjects. Researchers have found that the gender gap in math performance has been closing in recent years, yet male students are still overrepresented among the high test scores in the United States. A previous study used questions related to gender roles from the General Social Survey; however, the questions used did not measure the state's overall level of gender equality; they were just opinions on gender norms.

My research aims to analyze the level of gender equality and the gender gap in high-achieving test scores in individual states across the US to see if there is a correlation and, therefore, test another possible explanation for the lack of women pursuing graduate degrees in mathematics and mathematics-based careers despite reaching gender parity within standardized testing. I plan to combine gender-related data on the wage gap, poverty levels, reproductive rights, family demographics, workforce participation, and political participation to measure gender equality in each state. I will use data from the National Assessment of Educational Progress for the test scores because they provide data by state, subject, gender, and age, and I will control for the education funding in each state.

Sophie Eisenberg

Increasing the information transfer rate of inner speech-EEG brain-computer interfaces through a novel combination of features from various domains

Mentor: Dr. Aya Khalaf,
Yale University

A brain-computer interface (BCI) enables people with severe disabilities to control external devices using their brain activity, often measured via electroencephalography (EEG). EEG signals are non-invasive and low cost, but they are susceptible to noise (e.g., eye blinks), making it difficult to accurately differentiate between intentions, such as inner speech (IS) commands (e.g., thinking the words left and right). IS provides a more natural and efficient control method but is difficult to decipher because it involves more complex neural processes. A machine learning classifier (MLC) is then trained to interpret EEG signals and predict the intention of a new signal.

To address EEG and IS limitations and improve MLCs, it is essential to identify techniques that extract the most relevant information or features from signals. Features can be extracted from various domains, such as the time (change in EEG over time), frequency (distribution of activity across different signal frequencies), time-frequency (change in frequency over time), spatial (distribution of electrical activity across the scalp), and spatial frequency (distribution of frequency across the scalp). Integrating features from multiple domains allows a classifier to capture more comprehensive brain information, increasing a BCI's robustness and information transfer rate (ITR). ITR measures the amount of information transferred in bits per minute, taking into account both the speed and accuracy at which a BCI could work in real time. A higher ITR suggests a more effective BCI, but ITR has not been used yet to assess IS-EEG-BCIs.

Thus, my project aims to increase the ITR of IS-EEG-BCIs through a novel combination of features from the aforementioned domains. I will evaluate the features of the "Thinking Out Loud" dataset, which consists of EEG signals for the IS intentions left, right, up, and down (in Spanish). I will extract commonly used features from each domain and employ the rank sums algorithm to select the most informative features. I will use the support vector MLC to distinguish between intentions. Finally, I will assess the BCI using metrics ITR and accuracy for both left vs. right and up vs. down EEG-IS signals.

Ilan Epstein

Site-specific incorporation of methylarginine into proteins using mutant leucyl-tRNA synthetase

Mentor: Dr. Minkui Luo,
Memorial Sloan Kettering Cancer Center

Arginine is one of the twenty common amino acids that make up proteins, and it is unique for its positively charged side chain. Once a protein has been synthesized, arginine inside it can be modified by adding or changing groups of atoms, leading to changes in the protein's structure and overall function. One of these modifications is the addition of a carbon bonded to three hydrogens, which is called a methyl group. Arginine within proteins can be modified into three types of methylarginine by enzymes called protein arginine methyltransferases (PRMTs), and the modification changes the amino acid's charge distribution, size, and hydrophobicity. Several proteins containing methylarginine modifications are fundamental to the proper regulation of DNA transcription and cell signaling. Unfortunately, PRMTs aren't great for engineering proteins that are methylated at specific arginine sites because the enzymes rely on target sequences that a protein may not have. To get around this problem, scientists created two different methods of chemically synthesizing methylated proteins, but the involved reactions can be complicated and may require the steps to be performed manually. Therefore, it would benefit scientists to have an easier and more accurate way to make proteins with site-specific methylarginine modifications.

In my project, I am developing a novel method of acquiring proteins with site-specific methylarginine modifications by taking advantage of the natural protein synthesis pathway rather than relying on chemical methods. Proteins are synthesized based on the combinations of three base pairs contained in a DNA transcript, called codons, which signal for another amino acid to be added to the growing chain or to stop the synthesis process. I will reassign the TAG stop codon to methylarginine and am currently designing a novel protein that can bind to and install each of the three methylarginine variants at this codon, leading to their incorporation in proteins. The novel protein, designed from the enzyme Leucyl tRNA-synthetase, will be regulated based on the concentrations of methylarginine in the cell's environment. I will test this system in bacterial and mammalian cells to ensure it can be used to study arginine methylation in all life forms.

Dylan Freedman

sTREM2 & R47H-sTREM2's impact on tau aggregates in Alzheimer's disease

Mentors: Dr. Li Gan and Dr. Wenjie Luo,
Weill Cornell Medicine

Alzheimer's Disease (AD) is the most common type of dementia that begins with mild memory loss and deteriorates over time. In the brain, AD disrupts processes vital to neurons –including communication, metabolism, and repair– leading the neurons to ultimately die. AD is associated with both tau and neuroinflammation pathologies. Tau, a protein inside neurons that helps regulate their function in the brain, accumulates to form "tau tangles" in AD that block neurons from performing their functions. This disruption contributes to the cognitive decline in AD. Neuroinflammation, the activation of the brain's immune system in response to an inflammatory challenge, is also closely associated with AD. An overactivation of microglia, immune cells that normally clear waste out of a healthy brain, can cause neuroinflammation in the AD brain. Microglia can function due to receptors on cells known as myeloid cells 2 (TREM2). Soluble TREM2 (sTREM2) is the split fragments of TREM2 that can be found in the extracellular space of the brain. A common mutation of sTREM2 is called R47H-sTREM2, which is known to disrupt the process of microglial activation.

We know sTREM2 plays an important role in regulating microglial function, and levels in the brain vary depending on the stage of AD. However, there is conflicting data on how an increase in sTREM2, as compared to an increase in R47H-sTREM2, impacts the levels of tau in the AD brain. My study aims to address the following two questions: 1) What is the relationship between sTREM2 and tau in the AD brain? 2) How do the effects and amount of tau tangles of sTREM2 compare to those of R47H sTREM2?

To answer these questions, I will be working with a model known as a human neuron-induced pluripotent stem cell and inducing increased sTREM2 in my first model and increased R47H-sTREM2 in my second model. Then, I will compare the levels of tau in both models and a control model using immunofluorescence staining. The implications of my study include learning more about the AD brain as well as coming up with possible targets for treatment.

Sofia Guzzoni

Development of susceptibility to visual and auditory stimuli in children aged 7 to 19

Mentors: Dr. Joshua Kantrowitz,
Columbia University,
and Dr. Antigona Martinez,
Nathan Kline Institute for Psychiatric Research

Schizophrenia is a neurodevelopmental disorder characterized by visual and auditory hallucinations, which are perceptions in the absence of external stimuli. It is a complex neurodevelopmental disorder that does not present physical symptoms or clear warning signs until later in adolescence and even adulthood. Impairments in the auditory and visual systems contribute to social cognition deficits, making it difficult for the individual to interact socially. This is observed in individuals with schizophrenia and includes difficulties in discerning between two different tones, recognizing emotion through tone and facial expressions, detecting motion when presented with a moving stimulus, and determining whether there is a contrast between a stimulus and its background. Although these skills are known to be impaired in patients with schizophrenia, there is little research regarding how these visual and auditory skills develop in healthy children, making it difficult to discern when these neurodevelopmental impairments begin in patients with schizophrenia. Furthermore, all previous research has been performed using small age ranges, not capturing the whole development of the visual and auditory systems. Therefore, more research must be done on these mechanisms over a wider age range.

I will be collecting data from students ranging from 1st to 12th grade using a series of tasks. The visual stimuli being used will require students to determine motion, contrast, and facial expressions, while auditory stimuli will require students to discern between tones and match them, as well as to determine the emotion of a presented facial expression. My study aims to bridge this gap by investigating the developmental trajectory of auditory and visual processing skills across a wide age range, from early childhood to late adolescence. I will be studying the relationship between the data I collect on healthy developing children by comparing it first to healthy adults and then comparing the data I collect to that from people with schizophrenia. This comparison will help me gauge when performance on tasks becomes dramatically different from patients with schizophrenia and when performance becomes the same as healthy adults, helping me understand when neurodevelopmental impairments associated with schizophrenia may begin and how they progress.

Max Scheinfeld

Use of iPSCs to compare antisense oligonucleotides and CRISPR/Cas13 in targeted knockdown of long noncoding RNA ANRIL

Mentors: Dr. Luis Padilla Santiago and Dr. Kristin Baldwin,
Columbia University

Coronary Artery Disease (CAD) is a disease that involves the buildup of plaque, which eventually causes a heart attack or a stroke. Roughly 10-15% of genetic CAD can be traced to one gene called Antisense Noncoding RNA in the INK4 Locus (ANRIL). ANRIL is an RNA that doesn't make any proteins. The main function of the gene that codes for it is to regulate gene expression.

ANRIL comes in long and short isoforms (forms of expression), which are thought to be connected to CAD and cancer growth, respectively. Among these ANRIL isoforms, the ones that are connected to the risk of CAD or cancer are called Risk isoforms, and the ones that are not are called Non-Risk isoforms.

Two novel methods proposed to knockdown (or suppress expression of) Risk ANRIL are CRISPR/Cas13 and Antisense Oligonucleotides (ASOs). ASOs are a method which involves targeting the mRNA, or instructions for isoforms in order to turn them off, while CRISPR/Cas13 works by going to the isoforms themselves and breaking them down.

Researchers understand that ANRIL is linked to CAD but do not understand exactly how it operates or what we can do to prevent it from causing CAD in people. VSMCs (vascular smooth muscle cells) are important to study because Risk ANRIL in these cells is thought to contribute to the buildup of plaque that causes coronary artery disease.

My project aims to understand the functions of the isoforms and understand if ANRIL can be suppressed in the early stages of the development of VSMCs. We also aim to see if it is possible to save VSMCs that are exhibiting CAD and attempt to revert them to their regular function without CAD. We will use VSMCs and then test if we can knockdown expression or suppress the VSMCs from causing CAD and also if we can save or protect VSMCs in this state and turn them back into normally functioning VSMCs. We will do this by comparing the effectiveness of CRISPR/Cas13 and ASOs.

Jada Sosa

Using a DCNN model with an LSTM layer in multi-speaker environment with EEG and multiple speech envelopes

Mentor: Dr. Vinay S Raghavan,
Columbia University

Humans have the incredible ability to focus on one speaker in a crowded setting with multiple speakers, such as a cocktail party. However, people who are hearing-impaired and use hearing aids or hearing devices cannot perform this task. This is called the cocktail party problem. Current hearing aids and assistive hearing devices are ineffective because they amplify all sounds, amplify the speaker you are looking at, or can only suppress background noise like the hum of an air conditioner. These current methods make it difficult for those who are hearing impaired to be satisfied in their social lives and are more likely to struggle with mental illness.

Previous research has found great potential in using neural network models, which are machine learning methods that learn what to output through training, to make a hearing aid that gives the listener the ability to pay attention to one speaker. The neural network models accomplish this by performing a classification task that successfully identifies the speaker the listener is paying attention to, the attended speaker. The visual representation of each speech, called speaker envelopes, and the EEG, a recording of the listener's brain's electrical activity, are input into the model. The model processes each of the inputs and puts them into the same embedding space so they can be easily compared. The model then identifies the speech envelope that corresponds to the EEG recording as the attended speaker. Previous research has found success using convolutional neural networks (CNN) and CNN with a long short-term memory (LSTM) layer. CNNs are proficient in processing complex visual information such as EEG recordings, while the LSTM layer is used to process temporal information like a speech envelope over time.

My study aims to increase the accuracy of the neural neural network model. In my study, I will test the accuracy of performing the classification task on dilated CNN (DCNN) with different sets of parameters, which are factors like layers that affect the performance and training time of the model. I will also test the accuracy of a DCNN model with an LSTM layer and a baseline CNN model.

MEET THE CLASS OF 2026!

Ari Alexander

The influence of attachment style and Five Factor Model trait profile on turning-point events in teacher-student relationships

Mentor: Dr. David Poling,
Appalachian State University

Teacher-student relationships (TSRs) are defined as interactions that lead to emotional connections between a student and a teacher. These are important to understand because there is a large body of evidence tying TSRs to students' academic performance and mental well-being in school. Relational *turning-point events* (TPEs) are events that cause a change in a relationship. TPEs in TSRs are interactions that cause a student or teacher's opinion of the other to shift. TSRs can be studied using the attachment theory and the Five Factor Model (FFM). The *attachment theory* states that one's methods of dealing with and creating relationships are a result of how one's primary caregivers treated them as a child. Attachment theory can be used to analyze how people handle relationships in their lives, including TSRs. The FFM offers a classification system that uses five main traits (agreeableness, extraversion, conscientiousness, openness, and emotional instability) to describe one's personality and provide insight into possible life outcomes. Because attachment theory assesses relationships and personality impacts a person's outlook and "performance" in life, the combination of the two frameworks can provide insight into the intricacies of TSRs.

Previous studies have identified correlations between TSRs, attachment, and FFM trait profiles. However, research has primarily focused on TPEs in TSRs in a college setting, and therefore, there is limited knowledge on K-12 settings. There are also no studies examining attachment and the potential effects of the FFM trait profile on TPEs in TSRs.

The current goal of my project is to assess whether K-12 students' attachment and FFM trait profiles influence the types of TPEs they tend to experience in TSRs. If an association is found, I would further this question by assessing *how* TPE tendencies are influenced. Understanding this can allow teachers to predict what behaviors certain students respond well or badly to, likely improving overall TSR quality. I will conduct a survey-based project, collecting quantitative data for attachment and FFM trait profiles through numbered response points on a scale ranging from "strongly agree" to "strongly disagree" and qualitative data through short-answer responses from students on TPE experiences in their TSRs.

Ashley Cai

How lactic acid bacteria can be engineered to address different concerns of diabetes

Diabetes is a metabolic disorder that causes high blood sugar levels due to either insufficient insulin production by the pancreas or the body's inability to use insulin effectively. Insulin is a hormone that helps regulate blood sugar levels. Without proper management, diabetes can lead to serious complications affecting various organs and systems in the body, such as the heart, kidneys, pancreas, and more. There are two types of diabetes: Type 1 (T1D) and Type 2 (T2D). T1D is when the immune system attacks and destroys the cells in the pancreas that make insulin. T2D develops over time and occurs when the body becomes resistant to the effects of insulin or when not enough insulin is produced to keep blood sugar levels balanced.

Diabetes requires monitoring blood sugar levels, having a healthy lifestyle, and taking medications. Medical research has led to various treatments (medication, insulin treatments, glucose monitoring, and more), but there is no direct solution or cure for diabetes. Regular medical check-ups and education about the condition are essential for effective management and prevention of complications. There have even been treatments for side effects of diabetes, such as foot ulcers, but the treatments aren't effective long-term or aren't cost-efficient.

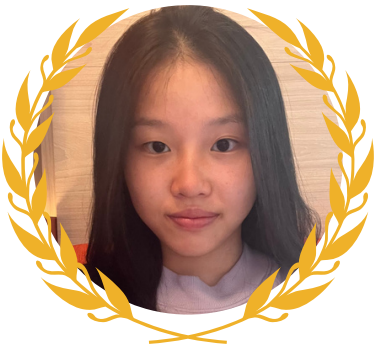
Lactic acid bacteria (LAB) are a group of bacteria that produce lactic acid and are found in foods such as yogurt. LAB can be easily genetically engineered to produce metabolites such as proteins, enzymes, etc. LAB can be engineered to help address some aspects of diabetes, including managing the side effects or controlling glucose levels. LAB can help address diabetes by creating metabolites that maintain glucose levels or producing medication that helps with some of the side effects.

Ethan Cho

Pain's influence on cognition

Pain serves as a warning signal to the human body. The two main types of physical pain are visceral pain, which originates in the organs or blood vessels, and somatic pain, which originates in the skin, bones, tissues, or muscles. There are many brain regions where pain receptors give data on where pain has been caused, such as the anterior cingulate cortex. When humans or other animals experience pain, there is interference with cognition. Past studies show that visceral pain causes a greater amount of cognition problems compared to somatic pain, yet this follows an unreliable trend. Chronic pain is the constant feeling of pain over a long period of time commonly associated with chronic diseases. It could be possible to cure chronic pain with more knowledge of how other factors influence those with chronic pain conditions by being able to neutralize a certain pain hormone with a special kind of medication. However, due to the brain's complexity, researchers cannot understand how exactly the brain processes pain.

Current knowledge on visceral pain and somatic pain state that both are similar throughout patients with all kinds of pain tolerance, although visceral pain is thought of as more painful. When visceral pain is experienced, there is increased activity in some of the same brain regions as when somatic pain is experienced, such as the cingulate and insular cortex. Furthermore, researchers observed stress levels and cognition to see how they affect or are affected by somatic and visceral pain. Using fMRIs, brain scanning devices that observe blood flow to the brain, it is possible to identify the brain regions involved in processing pain. Future research shows promising methods of studying the brain to figure out the brain's way of processing visceral and somatic pain and how they differ.



Madison Cho

Learning in organisms with decentralized nervous systems

Organisms with decentralized nervous systems typically lack a brain and other components that assist in maintaining an organized structure of neurons, nerve cells that send electrical messages throughout the body and allow for communication, movement, and other essential processes. However, some organisms have a brain but still have a distributed network of neurons, so the term was broadened from decentralized to relatively decentralized nervous systems. Researchers have inquired about how organisms with relatively decentralized nervous systems can learn and to what extent their cognitive capabilities reach (acquiring knowledge through experience and senses). Understanding how interactions between the widespread arrangement of nerves induce behavioral and mental activities can lead to insight into the neural basis (the biological processes defining perception and self-understanding) of these organisms and also of humans, who have a substantially more complex nervous system.

Types of basic forms of learning include habituation, the process by which a response to stimuli decreases over time, and sensitization, the process by which a response to stimuli increases over time. These learning structures have been observed in many different animals, such as box jellyfish and squid. In certain studies, a more advanced type of cognition called associative learning (the action of changing behavior due to making connections between multiple stimuli) has been observed. However, while the claim that organisms with relatively decentralized nervous systems are capable of learning is corroborated by multiple experiments, many studies tend to focus on only a handful of species. Consequently, there remains a lot of missing and incomplete knowledge on the learning capabilities of numerous organisms, including the variations between the diverse nervous systems within the broad category of decentralized. Additionally, the mechanisms underlying neuron interactions that evoke learning processes and behavior are not well known. Researchers are working to utilize imaging techniques, such as magnetic resonance imaging (MRI), which indicates different regions of the brain, to obtain a better understanding of neural activity in these structures.

Anker Ford

Jury bias

Jury bias occurs when a person or multiple people on the jury have a preference for the outcome of a case that disregards the evidence presented. The Jury Bias Scale (JBS) is a test a juror takes to determine whether they display signs of bias. Most of the time, jurors don't even know they are being swayed by internal bias, which is why juror bias-telling tests, like the JBS, are necessary.

While it is known how to detect jury bias using a test, there are many things we don't know. For example, researchers don't know how judges can affect a jury's judgment. Judges, like jurors, can also be subject to bias and have more say in cases than jurors. This is significant because, in some trials where the judge is the jury, they have all the say in a case. Some rulings a judge can make to affect the jury are based on objections. Objections occur when a lawyer feels a question or document is outside the rules of what can be admitted in court. If a judge omits certain evidence due to an objection with no ground, the jury can develop certain thoughts that alter their ruling.

Bella Iosilevich

Studying cognition through the influence of memory and emotion on decision-making

Mentor: Dr. Jennifer Mangles,
The City University of New York

Cognition refers to the mental processes of acquiring and implementing knowledge into decision-making or action. This neurological process is influenced by memory and emotion, and the result varies per the individual. Despite this understanding of cognition, there are several understudied areas in fully understanding cognitive functions, especially regarding the influence of emotion and memory on decision-making. For instance, the ways in which these cognitive influences affect decision-making are not studied on the individual level; instead, they are studied by groups of people, which leads to less specific individual-level data. Studying individual differences in how emotion and memory influence decision-making is important because it aids in the understanding of the personalized nature of cognitive processes.

To study how cognitive influences affect decision-making, neuroimaging techniques can be used, such as functional magnetic resonance imaging (fMRI) that tracks blood-oxygen activity in the brain and an electroencephalogram (EEG) that traces electrical signals in the brain. These imaging techniques can be used to study individual differences in neurology in the future rather than a larger study with potentially ambiguous results. By using these techniques to compare individuals of different cognitive abilities, researchers can identify neural signatures in decision-making activities that are influenced by memory and emotion, which can uncover the mechanisms that contribute to cognitive differences. Addressing the lack of research in cognition and decision-making is vital for understanding how memory and emotion shape decision-making processes, as well as the neural processes supporting these cognitive functions. Additionally, from this knowledge, therapies can be created to create cognitive disorders surrounding memory and emotion. For instance, Alzheimer's disease and depression are disorders that can be further understood through studying the effects of memory and emotion on cognition.

Brij Kapadia

Thermodynamic topology of quantum Reissner–Nordström black holes

Mentor: Dr. Wen-Xiang Chen,
Guangzhou University

There is a lot we still do not know about gravity. One example is in the case of a black hole in which the established theory of gravity, General Relativity (GR), does not give a complete picture. A black hole is unique due to its structure of matter. Imagine compressing a tennis ball. While compressing it, the amount of compression done reaches a certain threshold at some point. Afterward, the tennis ball transforms into a black hole. A black hole is just a bunch of matter compressed as much as possible.

GR is a mathematical model that takes in information about a black hole, like how heavy it is, and then spits out everything else we would want to know. One property of a black hole is that no experiment can be done that will give us information about its inside. Thus, mathematical models, like the ones derived from GR, are the only current way to learn about the inner workings of a black hole. However, GR is not perfect; at some points in a black hole, the mathematical models output an error. Is there a mathematical model that does not output errors and will enable us to understand the inside of a black hole?

In my research project, I will use a theory known as *f(r)* gravity, which can be used to make mathematical models. Additionally, I will use a value known as the Topological Number. This number is like a summary of a black hole; the key features of a black hole are encoded into this number. The process of my research project would be first to use *f(r)* gravity to come up with a mathematical model for a black hole. Then, using this model, I will calculate the Topological Number. Once I have obtained this number, I will be able to learn more about the inner workings of a black hole using a different model compared to a model originating from GR.

Chloe Lee

Racial and ethnic disparities in childhood cancer survival in cancer-specific institutions versus general hospitals

Mentor: Dr. Justine Kahn,
Columbia University

Pediatric cancer is one of the leading causes of death in children and adolescents in the United States. Although pediatric cancer survival rates have improved since the 1970s due to improvements in treatment, there are differences in survival by different demographic groups, such as race and ethnicity. Cancer survival rates are consistently lower for children of color, specifically Black and Hispanic children than for White children. The factors that cause these disparities are still being researched today. Once these factors are identified, researchers can investigate ways to mitigate them. Finding ways to mitigate survival disparities is important because every child deserves to have the same chance of life.

My project will aim to look at racial and ethnic disparities in pediatric cancer survival from patients who were treated in cancer-specific institutions compared to general hospitals. Cancer-specific institutions are places that research and develop better approaches for preventing, diagnosing, and treating cancer. Previous research has found that disparities between older and younger patients were mitigated in cancer-specific centers. However, there has been no research on this topic looking specifically at racial disparities in pediatric cancer. I hope to take datasets from these institutions and observe and compare survival trends, as well as look for other factors that may mitigate these disparities.

Ethan Lencz

Obedience to authority: Experimenting on the “experimenter”

Mentor: Dr. Tomasz Grzyb,
SWPS University of Social Sciences and Humanities

Obedience is a phenomenon in which someone does as a perceived authority figure tells or influences them to. The study of obedience to authority became popular with the experiments of Stanley Milgram. These experiments, which came after the events of the Holocaust, are focused on how seemingly ordinary people could be capable of committing horrendous atrocities. He designed his experiments to learn more about harmful obedience. These experiments tested how individuals responded to an authority figure instructing them to shock another human being. Milgram’s results showed high obedience rates in almost every variation of his experiments.

Milgram’s famous experiments included three roles, only one of which was a real participant, while the other two worked for Milgram. These roles were shocker (participant), victim, and instructor. Research on obedience through Milgram’s lens focuses on the shocker, but what about the person telling the participant to harm others (instructor)? Milgram and other researchers have not studied the potential obedience of someone in the instructor role. Adding another layer to the Milgram experiment, I will solely study the obedience of a participant telling someone to harm another person in some way, not the actual person doing the harming; in the real world, it may be even easier for someone to give harmful instructions than to commit harmful acts. Thus, the major question in my research is the following: will people obey orders to give destructive instructions to others in a similarly frequent fashion to what was seen in Milgram’s experiments, or will the change in responsibility dynamics lead to unexpected results?

Julian Lotke

Synergistic relationship between an endolysin treatment and Terpinen-4-ol when treating B. cereus

Mentor: Dr. Daniel C. Nelson,
University of Maryland

Bacillus cereus (*B. cereus*) is a very dangerous bacteria. This bacteria is so deadly because it has gained resistance to many antibiotics we use against it, making it extremely hard for us to treat these infections. Because *B. cereus* has gained antibiotic resistance, researchers must find alternative treatments for these infections. One novel way of treating *B. cereus* infections is by using endolysins, which are enzymes that can quickly destroy bacteria. To make endolysin treatments against *B. cereus* more practical, researchers must find ways to increase the bacterial destruction properties of these endolysin treatments. Currently, we can add antibiotics that *B. cereus* is not already resistant to into the endolysin treatments. While this does increase the bacterial destruction properties of the endolysin treatment, it also spreads additional unwanted antibiotic resistance across *B. cereus* bacteria. This is problematic as the increase in antibiotic resistance makes *B. cereus* increasingly harder to treat in the future.

In my project, I aim to find a compound that increases the bacterial destruction properties of an endolysin treatment without spreading additional unwanted antibiotic resistance across *B. cereus* bacteria. One promising compound is Terpinen-4-ol, which is found in tea tree oil from *Melaleuca alternifolia* and is hypothesized to increase the bacterial destruction properties of endolysin treatments against *B. cereus* without spreading antibiotic resistance. This is because Terpinen-4-ol not only has bacterial destruction properties against *B. cereus* but also destroys a thick film that surrounds and protects the bacteria from treatments. These two properties are often linked to the increase in bacterial destruction properties of endolysin treatments against *B. cereus*. Unlike conventional methods reliant on the addition of antibiotics in endolysin treatment, this strategy avoids spreading additional antibiotic resistance among *B. cereus* strains while still increasing the bacterial destruction properties of the endolysin treatment.

Sophia Nanian

Using brain organoids to model brain development and neurodegenerative disorders

Mentor: Dr. Chris Makinson,
Columbia University

Organoids are 3D structures that are grown from cells to replicate any part of the body. Unlike 2D models or animal models, 3D organoids have the potential to replicate human organs very closely. Since the growth of the organoids can be carefully observed, disease development and mutation growth can be seen and compared to similar events in the human body. For my research, I will be focusing on brain organoids. Brain organoids can help create patient-specific medicine because they are derived from human skin cells. To make a brain organoid, skin cells are induced with proteins to become pluripotent, which allows them to turn into any cell type in the body, turning them into induced pluripotent stem cells (iPSCs). By inducing them with specific brain-related growth factors, the cells can start forming neural qualities. Embedding the cells into a substance that helps them grow with structural support helps them attach and form into small tissues. The small tissues are then carefully cultivated to grow into a brain organoid.

Currently, many studies focus on using brain organoids to explore the origin, cause, and growth of developmental disorders seen in prenatal brains. Scientists are refining techniques to differentiate brain organoids to replicate certain parts of the brain. As organoid differentiation gets more exact, scientists experiment with introducing different mutations and genes that are associated with neurodegenerative disorders. Newer technology like CRISPR-Cas9, which is gene editing technology, can also be used to change organoid DNA to look more like certain disorders. One of the main limitations of organoids is that they cannot mature for long periods of time. Their differentiation process is also not specific enough to model certain brain regions with great accuracy. Brain organoids are also susceptible to death because homeostasis is hard to maintain in that environment. Scientists are currently trying to find ways to care for organoids better, make maturation happen faster, and create more specific organoids. For my research, I want to improve brain organoid models of developmental and neurodegenerative disorders.

Benjamin Ostow

Optimizing processing parameters and phase prediction in closed-loop NIBS

Mentors: Dr. Hamed Ekhtiari and Dr. Ghazaleh Soleimani,
University of Minnesota

Non-invasive brain stimulation (NIBS) is a technique that uses electrical currents to alter neural activity by changing the firing rate of active neurons. It can treat various neural conditions related to speaking, swallowing, movement, and cognition by priming the brain for a more significant response to behavioral treatments. The electrical currents are induced from outside the brain using scalp electrodes or an external magnetic field. Traditional NIBS uses an open-looped system, meaning that the stimulation device does not receive feedback from the brain. The lack of feedback from the brain is a significant issue because stimulation parameters such as frequency and intensity must be chosen before stimulation and cannot be altered based on the brain's response to the stimulation, meaning that the chosen parameters may not be optimal. Open-looped NIBS is not personalized, causing unpredictable variations in treatment outcomes. Therefore, my research will focus on closed-loop NIBS, a recent method of personalizing NIBS utilizing neuroimaging. Closed-loop NIBS differs from open-looped NIBS in that the stimulation device receives real-time neuroimaging feedback from the brain and can alter the parameters of the electrical currents to get the brain to match the desired brain state for treatment.

Since signal processing and filtering cause a delay in the measurement of neuroimaging signals, it is necessary to predict future signals. Prediction is based on the previously measured signals, so signal processing parameters can significantly impact the accuracy of neuroimaging signal prediction. Studies have tested various signal prediction algorithms and signal processing parameters, such as frequency and duration of signal measurements on neuroimaging datasets, and measured the difference between the measured signal and the predicted signal at particular time points. Future studies should aim to find the optimal way to synthesize neuroimaging data and to predict brain signals because there are still no generally accepted parameters. I plan to conduct research that helps improve the recent innovations in signal optimization algorithms or that investigates the effects of a specific signal processing parameter to improve the feedback received by the stimulation device.

Tenzin Paljor

Effects of COVID-19 on the heart

SARS-CoV-2 infiltrates the body by attaching to a specific receptor on certain cells called ACE2, allowing it to penetrate the cell membrane. Once inside the host cell, proteins are released, eventually leading to the virus multiplying within the cell and causing the disease COVID-19. Although the virus is commonly known to infect the lungs, many studies have shown that COVID-19 can also attack heart cells, such as cardiomyocytes and cardiac fibroblasts. If heart cells are damaged, this could cause various conditions like myocarditis, which is defined as heart muscle inflammation, or heart failure.

One of the most common outcomes is an arrhythmia, an irregular heartbeat caused by a dysfunction in the heart's conduction and electrical system. Although researchers can understand potential cardiac diseases caused by COVID-19, the connection between the virus and cardiovascular diseases on a more molecular level and how the virus interacts with heart cells is still unclear. By finding the key correlation between the heart and COVID-19, researchers can have a better understanding of how the virus works and create better treatments and advancements. This will help a wide range of people, ranging from older people at high risk of COVID-19 and cardiovascular diseases to children at low risk of COVID-19 and cardiovascular diseases.

Max Rerisi

Determining diabetic risk factors using machine learning models for feature importance

Mentor: Mathieu Ravaut,
Nanyang Technological University

Type 2 diabetes affects hundreds of millions of people worldwide, many of whom do not even know they have the disease. Diabetes arises from the body's inability to regulate blood sugar levels. If gone unnoticed and untreated, diabetes can cause severe, life-threatening symptoms. Changes like healthier diets or medication are necessary for people with diabetes to prevent fatal complications. Any technique that can provide further insight into the disease and diagnose individuals sooner can improve survival rates, and breakthroughs in the field can keep the number of new type 2 diabetics to a minimum. Previous studies have used machine learning (ML) to see how different amounts and thoroughness of data can improve performance. ML is a process that involves taking large amounts of data and training a mathematical algorithm to make predictions about new data by feeding it subsets of data.

In my project, I am attempting to provide insight into diabetes through these models. While they can be used to predict diabetes to varying degrees of accuracy, what I hope to do is apply a more useful technique that measures the weight, or importance, of each attribute the datasets have. The more important the attribute, the more related it is, directly or indirectly, to a patient's current condition or why they do (or don't) have diabetes. The combination of attributes with the source of the data can be used to conclude what causes the attributes to change and how or why they impact diabetes. This research and consideration can help protect against new cases of diabetes and can improve the condition of current diabetics as new insight is gained into what can cause negative symptoms. A particular example this can be applied to is the diet of Eastern vs. Western cultures. Determining fundamental nutritional differences in typical Eastern/ Western diets and their effect on diabetes is just one such case in these techniques, and this field can be utilized by comparing the differences between the types of patients and their medical information.

Logan Rogers

The efficacy of hydroxyurea in treating complications of sickle cell disease

Mentors: Dr. Lena Oevermann, ***Charité – Berlin University Medicine,*** **and Dr. Russell E. Ware,** ***Cincinnati Children's Hospital Medical Center***

Sickle cell disease (SCD) is caused by a mutation in hemoglobin, a protein found in red blood cells responsible for the transfer and storage of oxygen. Hemoglobin is made of four protein subunits (molecules that assemble together to make proteins). The mutation in the hemoglobin is caused by the substitution of amino acids within these subunits, arising from mutations in the DNA sequence. These mutated hemoglobin proteins tend to clump together due to their abnormal shape, forming long, sharp chains that pierce the membrane of red blood cells, causing them to collapse on themselves and form sickle-shaped cells. These sickle-shaped cells can clump to block the flow of oxygen and blood throughout the body, leading to many life-threatening symptoms such as strokes, organ damage, and severe pain episodes. Currently, a treatment called hydroxyurea is being tested for sickle cell disease treatment. Hydroxyurea is a daily oral treatment found to raise fetal hemoglobin levels in the body, which raises oxygen levels in the blood and improves blood flow. This, in turn, treats sickle cell symptoms. Hydroxyurea has great potential to be a leading treatment for sickle cell disease because it is effective and much more accessible than other conventional treatments.

While hydroxyurea has shown potential in treating the more common symptoms of sickle cell disease, its long-term efficacy and potential side effects are still unclear. Many tests have concluded that higher doses of hydroxyurea are significantly more effective when compared to lower doses; however, it is unknown whether this higher efficacy persists over a long period of time. In addition, the potential side effects of long-term hydroxyurea usage at high dosages are unknown. Hydroxyurea is suspected to cause infertility in male patients and stillbirth or miscarriage in mothers. Currently, researchers are looking for ways to abate side effects by testing how hydroxyurea at different stages of pregnancy and different stages of puberty affect fertility.

Henry Schiffman

Evaluation of novel therapeutic approaches for PMM2-CDG in vitro

Mentor: Dr. Tamás Kozicz,
Icahn School of Medicine at Mount Sinai

Many biomolecules, particularly proteins, have a biological function that depends on their three-dimensional shape. Glycosylation, defined chemically as the enzymatic modification of a protein or lipid with the addition of a sugar molecule, is a fundamental biochemical process existing among all domains of life that influences the 3D structure of proteins. This process, critical for modifying proteins and lipids, is essential for numerous physiological functions in all tissues, including cell-cell signaling, immune responses, coagulation, and the structural integrity of cells, as nearly all biological processes depend on the function of proteins. The modifying sugars known as glycans can vary drastically depending on the molecule being modified; thus, glycosylation involves many unique enzymes to work successfully. Congenital disorders of glycosylation (CDGs) are a diverse group of over 160 rare diseases caused by pathogenic mutations in genes involved in the glycosylation pathway. Given that the glycosylation pathway is present in all tissues, these disorders are characterized by multi-system manifestations, including neurologic abnormalities, cognitive delay, lack of coordination (ataxia), liver pathology, and abnormal fat distribution, among others. Due to the involvement of many different proteins in the glycosylation process, the severity of symptoms of someone with a CDG is on a spectrum, depending on the affected gene and the nature of the mutation.

Thousands of people globally are affected by CDGs. Currently, therapeutic options are limited, and most treatments are palliative, aiming to alleviate the resulting symptoms rather than the underlying cause. The most prevalent CDG is PMM2-CDG, a disorder caused by a mutation in the PMM2 gene. My project will focus on evaluating parameters such as efficacy, toxicity, and others to determine the potential of a novel therapeutic strategy targeting the underlying biochemical pathways of PMM2-CDG. To do this, we will leverage brain organoids derived from tissues of affected individuals as an in vitro (in an artificial culture rather than a living organism) medium for drug testing. The use of brain organoids for this type of experiment is compelling, as many CDGs, including PMM2-CDG, have highly evident neurological manifestations.

Lucy Sole

Commonly occurring technological challenges in adolescent type 1 diabetes treatment

Type 1 Diabetes (T1D) is a type of diabetes that affects approximately 1.45 million people in the United States. It is a chronic illness in which the patient's body is trained to attack the cells responsible for creating insulin, the hormone that helps blood sugar enter the body's cells. Without being able to synthesize insulin to process blood sugar and produce usable energy, a patient is incapable of maintaining essential functions such as respiration or cell growth and repair and cannot perform physical tasks such as work or exercise. Patients with T1D have to rely on external ways of getting insulin, the most popular one being a treatment called continuous subcutaneous insulin infusion (CSII). CSII treatments are a closed-loop system, which means that a blood sugar monitor can work in tandem with the auto-injectable insulin without any patient intervention.

Although the creation of CSII has made huge changes in the world of T1D treatment in terms of lifting the burden of treatment from their users, there are still unaddressed problems or parts of the device that can be improved to work faster or more conveniently. My research will focus specifically on the issues that affect the lives of children. One of the biggest problems is how frequently the compartments of the device have to be swapped and how they do not operate on the same schedule. For example, CSII is made of two main devices: the average insulin pump system, which has to be changed every 11 days, and an insulin compartment that runs out every three days. Although this issue doesn't affect how the device works, it is extremely inconvenient to the user. To solve this problem, I hope to create a way of expanding the insulin compartment in popular devices to allow it to operate on the same schedule as the pump.

Alexis Solomon

The relationship between sports participation and mental health in children and adolescents

Mentor: Dr. Scott Graupensperger,
University of Washington

Within a given year, 10-20% of adolescents experience symptoms of a mental health disorder; therefore, it is important for prevention efforts to be utilized and researched thoroughly. One way that may help protect or prevent mental health difficulties in children and adolescents is sports participation. Participating in sports has been shown to reduce the likelihood of experiencing anxiety, depression, and hopelessness and improves self-reported overall mental health. Current areas of research include the associations between sports participation and mental health. Researchers have found that type of sport (individual vs. team) and gender impact the relationship between sport participation and mental health.

In a few cases, the relationship between sports and mental health is mixed: on the one hand, sports are associated with developing positive well-being (self-esteem, social skills), but another study found frequent occurrences of psychological difficulties (pressure, burnout). In addition, it is unknown whether sex plays a role in the relationship. To address these gaps, researchers continue to study the general relationship, with emphasis on how certain factors, such as gender and type of sport, may relate to mental health differently. Other knowledge gaps include studies in underdeveloped countries and longitudinal studies, though there have also been efforts to address these gaps.

Dylan Spitalnick

The role of the gut microbiota in inflammatory bowel disease pathogenesis

Mentor: Dr. Karen Edelblum,
Mount Sinai School of Medicine

Inflammatory Bowel Disease (IBD) is a group of chronic, autoimmune diseases that induces inflammation in the gastrointestinal tracts of approximately 1.6 million people in the United States. IBD exists in two distinct forms: Crohn's disease and Ulcerative Colitis, with the main difference being where each disease occurs in the gastrointestinal tract. Although how IBD develops is unknown, the most accepted hypothesis is that it is triggered by environmental factors in a genetically susceptible individual. One of these environmental factors, the gut microbiota, has been heavily studied due to its significant influence on IBD development and its potential therapeutic value. The gut microbiota is the collection of all microorganisms living in the gut and performs various functions, from helping with food digestion to regulating the immune system. The microbiota is highly diverse in a healthy individual, with many microorganisms creating necessary chemicals humans cannot produce. This microbial diversity is lost in the microbiota of IBD patients, leading to many anti-inflammatory, beneficial microorganisms being replaced by disease-causing ones.

A large gap in researchers' understanding of the microbiota's role in IBD development is how it interacts with the immune system. The immune system perpetuates inflammation in IBD patients and is currently targeted by most treatments, so understanding how the microbiota interacts with it is crucial. However, due to the complex nature of IBD, it is difficult to map out these interactions as they occur differently in every patient. To address this issue, many mice studies have been conducted in controlled environments where the mice's microbiota and immune system can be manipulated. These studies have not shown definite results but point towards the microbiota exacerbating inflammation rather than inducing it. Studies have also shown that certain microorganisms can lead to the development of specific immune cells, which are thought to be responsible for inappropriate immune responses in IBD patients.

Keynote Speaker

Yuqiao Zou

ASR Class of 2022

Yuqiao joined ASR during its very first year at CGPS. He did his ASR project, titled "Developing Photo-crosslinking Peptide Probes as Substrate Mimics to Trap Protein Lysine Methyltransferases," over two summers at the Memorial Sloan Kettering Cancer Center. The money the school received due to Yuqiao's semifinalist title at the Regeneron Science Talent Search went toward purchasing the Yuqiao Zou Supercomputer, which has now been used by several ASR students with computationally demanding research projects.

He is now attending Washington University in St. Louis where he is majoring in Chemistry with a Biochemistry concentration. He is also minoring in music (piano). This summer, he will be a Teaching Assistant for the Chemistry in Society course at Johns Hopkins' Center for Talented Youth summer program.

We are very excited to have him here to speak at the ASR Symposium!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Thank You!

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Mentors: for your guidance and support of our projects

CGPS Maintenance: for setting up the Symposium spaces

... And anyone else we may have forgotten! We are grateful to everyone who made this Symposium and class possible. It takes a village to raise a scientist!

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