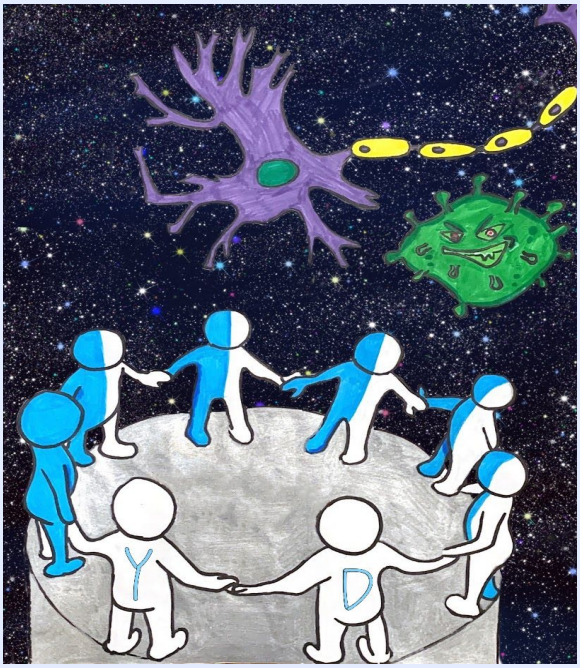
New Beginnings: Six Feet Apart into the Unknown

Advanced Science Research 2020 Symposium



Original artwork by JingChen He

The important thing is not to stop questioning. Curiosity has its own reason for existing.

~Albert Einstein

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A Note of Thanks

From all the students of Advanced Science Research, thank you for those who have made this ASR Symposium and our class possible. Thank you to our wonderful ASR teachers, Mr. Ilya Yashin and Mr. David Keith. Thank you to our great administration: head of school Dr. William Donohue, prep school director Ms. Joanie Dean, science department head Ms. Patrice Buckley, and deans Ms. Michelle Schackman, Mr. Victor Puccio, and Mr. Scott Wilson. Thank you to Mr. Adam Gerson for helping us with technology. Thank you to our mentors, who have graciously volunteered to help support and guide us through the research process. Thank you to our parents, who have supported us through the entire rigorous process of ASR. Finally, we thank the Board of Trustees for making this course a reality.

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The inaugural CGPS Advanced Science Research Class

A Message From Dr. William Donohue, Head of School

Dear CGPS Community,

One of my great regrets about not being on campus during the spring of 2020 is that we will not be together to celebrate the inaugural year of the Advanced Science Research Program at the first ASR Symposium. If there can be a positive consideration about the impact of this pandemic, it is the ironic fact that in future years we will no doubt see student research projects inspired by this period of self-isolation and quarantine.

Despite my disappointment, I am enormously proud of you as student pioneers, who have taken on the challenge of Advanced Science Research. I have watched with admiration as you, with great dedication and trust, have followed the path laid out by Mr. Yashin and Mr. Keith. It is particularly gratifying to hear them boast about your work — your teachers' pride in you is palpable! I know from attending several of your presentations in-person that your diligence is paying off. My experience tells me that you are on your way to great success. I believe you are adding another “jewel” to the crown that is Columbia Prep.

I look forward to the Symposium and learning more about your research.

Sincerely,

Bill Donohue
Dr. William Donohue
Head of School

A Message from Ms. Joanie Dean, Prep School Director

The Columbia Prep Advanced Science Research class is truly one of a kind. In this course, students conduct high-level research in many fascinating scientific topics. From stem cell research to the study of neural networks, our high school students' independent work is both rigorous and inspiring. Students engage in university-level research, writing, and presentations, and no matter their future life's work, this experience is life-changing for each and every student. At Columbia Prep, we are extremely proud of our outstanding Advanced Science Research program.

Ms. Joanie Dean
Prep School Director

A Message from Ms. Patrice Buckley, Science Department Head

The Advanced Science Research program at CGPS allows students to delve deeply into a topic and spend three years of high school becoming an expert on that topic. It is an amazing opportunity that allows students to develop skills in so many areas such as research skills, working with scientists, and presentation skills. I spent most of my career working in either clinical or research laboratories. When I made the switch to teaching, one aspect that I really enjoyed about teaching was introducing students to research and laboratory techniques. It is challenging to fit research into my high school courses. ASR allows students who are passionate about science to pursue their interests guided by an excellent coach - Mr. Yashin. Under his guidance, students hone their skills and present their unique findings to the school community and beyond.

Ms. Patrice Buckley
Head of Science

A Message From Mr. Yashin, ASR Instructor

At first, I did not want to teach ASR.

When Ms. Dean asked me to consider being the instructor of this new program, I said, no thank you. I thought it would be a soul-crushing factory churning out science fair competitors whose closest contact with authentic research is pushing buttons as directed by some professor somewhere. I wanted no part in this travesty of science.

It took Mr. Keith only an hour and a half to convince me that my notion of ASR was diametrically opposite to what the program stands for at its heart. Having had no direct experience with it, I took his words on faith and decided to give it a try. It was the best decision I'd made in a while.

The students whose work you see here had to make a similar leap of faith. With no ASR upperclassmen to ask for an insider's report, they had to take on faith that the eventual payoff is worth the daunting amount of work and that the unusual way the class runs is the best way to get there. And here they are, at the end of the first year, an order of magnitude more mature and ready to contribute to science in an authentic way than just nine months ago.

ASR is more than just the sum of its parts; it is more than just six independent studies who happen to meet in the same room and with the same teacher. I am lucky to be a part of the beginning of ASR at Columbia Prep and witness the students' inspiring growth and successes. They have set the bar high this year. Here's to many more years to come.

Mr. Ilya Yashin, ASR Instructor

Introduction to Student Abstracts

What is an abstract?

In scientific literature, an abstract is a paragraph that summarizes the content of the article: The relevant literature, hypothesis, methods, results, and a summary of the importance of the research in context. As this is the first year of ASR at CGPS, students have not yet had the chance to complete a research project. Instead, we have written about what we have been learning this year and about our future research goals.

The Modeling of Neurological Disorders Using Induced Pluripotent Stem Cells

Author: Akshay Shivdasani

"Researching a cutting-edge field of science that has the potential to save lives has truly been one of the peaks of my life."

Human induced pluripotent stem cells (IPSCs) have opened up new possibilities in the study of neurological disorders, as they have the potential to form every type of cell in the body. IPSCs are derived from an already specialized cell, like a skin or blood cell, and are reprogrammed into a fetal-like state of pluripotency through the introduction of reprogramming genes. One of the most promising uses of IPSCs is the formation of organoids. Organoids are simplified, miniature versions of the body's organs grown *in vitro*. Organoids can be used to model disorders, allowing for the study of the behavior of these disorders. This method of studying neurological disorders may enable the discovery of novel pharmaceuticals and genes that may be able to inhibit the effects of these disorders. This can be most effectively done through a process called high-throughput screening. This type of analysis tool is an automated method of testing thousands of pharmaceuticals on cell cultures until a chemical compound is found that is effective against a neurological disorder. Akshay and his mentor, Dr. Alice Giani, plan to model Zika in iPSC-derived neurons whose genome contains a "gene of interest" to test whether this gene will inhibit the virus more effectively than iPSC-derived neurons modeling Zika that do not contain this gene.

Mentor:
Dr. Alice Giani
Weill Cornell Medicine
Laboratory of Shuibing Chen
New York City, New York

The Impact of COVID-19 on the Driving Patterns of Individuals with Preclinical Alzheimer's Disease

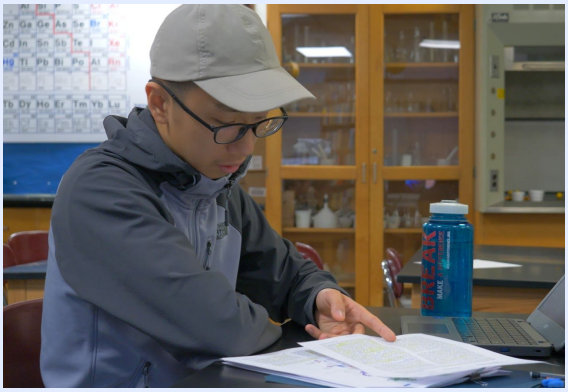
Author: Fabiha Rafrafin

"Most times, things don't go your way, but when they do, it's pretty amazing."

Alzheimer's Disease (AD) is a progressive brain disorder in which brain cells and brain cell connections degenerate and eventually die, causing a deterioration of memory and various mental functions. AD presents itself in both preclinical, asymptomatic, and symptomatic stages. Underlying AD pathology, such as amyloid plaques, which are aggregates of misfolded protein, are present during the preclinical stage, but cognitive symptoms are not; cognitive symptoms, such as memory loss, confusion, and difficulty with language, are present in the symptomatic stage of AD. Currently, there are over 35 million licensed drivers who are above 65 years of age in the United States, and as this number increases, so will the number of motor vehicle crashes and fatalities, as older adults are at a much higher risk of dying in a crash than younger ones. Therefore, it is important to be able to identify those individuals who will be at most risk of driving skill decline and when that decline will occur, so that safety measures can be implemented early on. Preclinical AD, during which symptoms of dementia are not present, has been associated with driving impairment, and persons with preclinical AD exhibit different driving behaviors than those without it. However, the extent to which preclinical AD affects daily driving is still unknown. Fabiha will be conducting a study on the impact of the presence of preclinical AD on driving behaviors from before and after the acceleration of the spread of COVID-19 in the US, from March 2020 to April 2020.

Mentor:
Dr. Catherine Roe
Washington University School of Medicine
St. Louis, Missouri

Chemoenzymatic Approach to the Synthesis of Human Milk Oligosaccharides



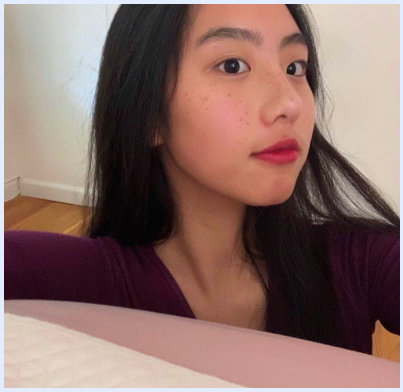
Author: Yuqiao Zou

"Lunch and research really go together. They both need to be thoroughly digested."

Glycans are polysaccharides, meaning they consist of monosaccharide sugar molecules joined together, and are found within the human body. Glycans can regulate intracellular recognition, provide structural stability, and function as a source of energy for cells. Human milk oligosaccharides (HMOs) are a key class of glycans found within human milk. HMOs are able to regulate an infant's gut microbiome as well as the development of the infant immune system. Currently, the compound lacto-N-neotetraose (LNnT), which can be further modified into other HMOs, has been made readily available. More complex HMOs, however, cannot be produced on a large scale, making them difficult to research. In addition, their lack of accessibility is preventing them from being used as potential supplements in infant formula. This is mainly because of the asymmetrically branched structures of many HMOs, requiring monosaccharide units to be added at one branch but not the other. Yuqiao aims to utilize substrate selective enzymes, which are enzymes that only catalyze the reaction between two specific reactants, to selectively install monosaccharide units at a specific branch of the molecule. By automating the use of substrate selective enzymes, Yuqiao hopes to enable the large-scale production of complex HMOs.

Mentor:
Dr. Minkui Luo
The Minkui Luo Lab
Memorial Sloan Kettering
New York, New York City

Diagnosis and Classification of Early-stage Autism with MRI



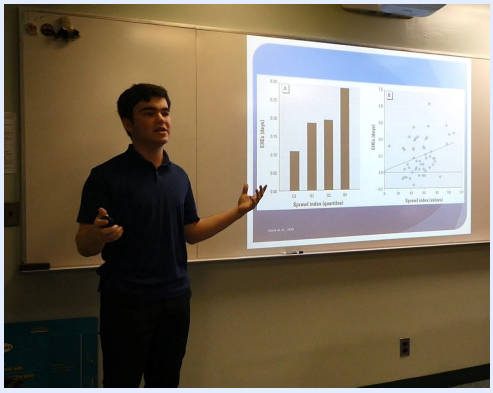
Author: Siyang Wei

"Follow your interest, face your challenges, and don't panic."

Autism spectrum disorder (ASD) is a neurodevelopmental disorder relating to people's cognitive skills including the ability to perceive and socialize with others. It is known as a "spectrum" disorder because there are various types and severity of symptoms in people with ASD. There are no medications for curing ASD, only those that can help related symptoms such as depression, seizures, insomnia, and difficulty with focusing. Autism is usually diagnosed with abnormal behavior around the age of two to three years old. If we are able to diagnose autism at an early age, children will be able to receive better treatment, which is why neurologists are studying childrens' brain development with magnetic resonance imaging (MRI) to find a biomarker that can be used to diagnose autism. Dr. Gohel's work focuses on studying in the regions responsible for language and face processing, the ability to understand what others are thinking based on their behaviors, and the ability to replicate others, to find a biomarker that can be used to diagnose autism. Dr. Gohel and his colleagues examined different types of connectivity, such as small-worldness, for children with mild autism and children with severe autism as a function of brain sparsity. Their findings suggested that children with severe ASD showed an increase in clustering coefficient and small-worldness compared to those with mild ASD.

Mentor:
Dr. Suril Gohel
Department of Health Informatics
Rutgers University School of Health Professions
Newark, New Jersey

Using Urban Climate Modeling to Support Climate Change Adaptation in Urban Environments: A Case Study for New York City with Broader Implications



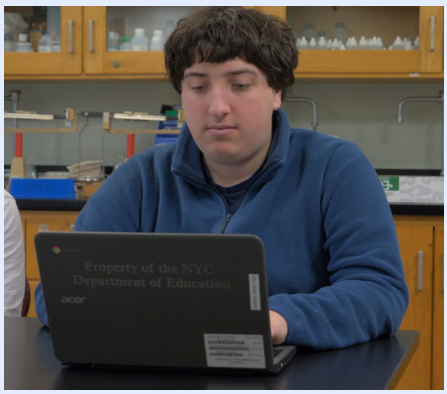
Author: Alex Sidorsky

"Learning and contributing to a field I am so passionate about has been one of the most rewarding experiences of my life."

In recent years, because of poor urban planning and design, the peaks and averages of temperature in our cities have risen and cities have not been able to adapt to this climate change. Furthermore, the temperature of cities is quickly outpacing that of surrounding areas. This phenomenon is known as the urban heat island effect. As a result, heat waves are more frequent and more intense, which leads to an increase in heat-related mortalities, one of the largest causes of death in the United States. In a time where 75% of the human population is expected to live in cities by 2050, research in this area is more important than ever. While much broad research has been done on this topic, little research is up to date about New York City. Alex's research in collaboration with his mentor, Dr. Prathap Ramamurthy, looks to provide us with an up-to-date analysis of New York City's urban climate, looking at multiple variables including air temperature, relative humidity, precipitation, and soil moisture. Specifically, Alex will look at land-atmospheric interactions, interregional differences in climate variables, and will aim to create a current heat index for the general public. This will all be done using computer modeling in an effort to direct NYC's plans for climate adaptation in the future.

Mentor:
Dr. Prathap Ramamurthy
City College of New York
Department of Engineering & NOAA-Crest Affiliate
New York City, New York

Prostate MRI Registration Using Siamese Metric Learning



Author: Alex Lyons

"It feels really accomplishing to know that I am doing research that I thought I wouldn't be doing until college."

Medical image registration is the alignment of one or more medical images with another image. The process of aligning two images involves adjusting one image so that it appears as if it were taken in the same place, at the same time, and with the same equipment as the other image. One example of image registration is the alignment of an MRI (magnetic resonance image) captured before a patient's surgery to an MRI of the same subject during surgery. This could aid the surgeon in monitoring the progress of surgery by eliminating the differences between the two MRIs that were caused by differences in how the images were captured. Since manual image registration, done by specialists, takes a long time to complete, computer scientists are working to create more efficient image registration methods using machine learning. A machine learning model is a coding algorithm that analyzes patterns within data and learns to output accurate results when presented with new data. One machine learning model, a Siamese neural network, can learn to break down two separate pieces of data into simpler patterns. Then, the model enters the collected patterns into a similarity metric, which is a system for measuring the similarity of data using the similarity of patterns within the data. Alexander and his mentor, Dr. Alberto Rossi, aim to create a Siamese neural network that can select the pre prostate biopsy MRI (out of numerous transformed versions of the MRI) that is most accurately registered to an MRI taken during the biopsy.

Mentor:
Dr. Alberto Rossi
University of Florence
Florence, Italy

Program Credits:
Content: Akshay Shivdasani
Design: Akshay Shivdasani and Alex Sidorsky