ASPIRE

ASDRP
Aspiring Scholars Directed Research Program

Spring 2021

A researcher newsletter of the Aspiring Scholars Directed Research Program

Announcements

We celebrated the end of the fall 2021 semester with "ASDRP Research Shorts".Visit the Research Shorts webpage @ www.asdrp.org

BASIS Independent High School Senior Projects.

Keep an eye out for the senior projects from our BASIS Independent High School researchers. All BASIS seniors must submit a research project in order to graduate. As the date draws near for their final research presentations, we will make announcements of how the ASDRP can support our BASIS Seniors.

High School Seniors

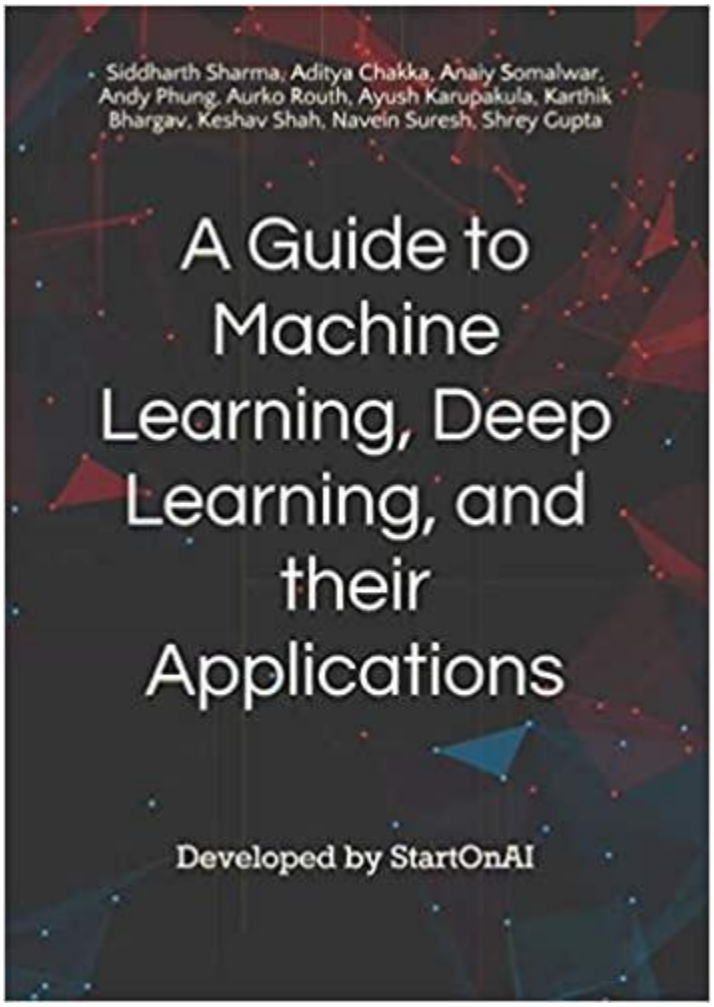
University & College admissions season is here! Congratulations to all our high school senior researchers for your hard work and dedication. We are immensely proud and know that any university or college is extremely fortunate to have an ASDRP researcher as part of their student body. Be sure to take time to enjoy the last part of your senior year.

Summer 2021 Semester Starts in June

It's hard to believe that another Summer Research semester is almost upon us. If you are planning on staying with us for another amazing summer of researcher, please speak with your advisor ASAP.

Publication Spotlight

Dr. Phil Mui, One of the ASDRP Leadership Board Members has published a book.



Find it on Amazon (not a plug for Amazon):
Deep learning is the fastest-growing subset of machine learning and is loosely inspired by biological neural networks. Now you may be wondering, why this book in particular? This book serves as a guide for both beginners and users of machine learning to become more familiar with the fields on both a theoretical basis and through a hands-on, practical example-based approach. Unlike other books on the subject, we use efficient, grounded tools to demonstrate the power of machine learning while guiding the reader from the fundamentals of data science and mathematics towards state-of-the-art algorithms and modern developments in the field.

"This book is a tour de force through the scientific aspects of AI by a group of impressive young authors. I strongly recommend it." - **Bernard Widrow, Prof. Emeritus of electrical engineering, Stanford University.**

Student Research Updates

The Intersection Between QFT and Particle Oscillations

Contributed by Ananya Balaji

10th Grade, West Windsor-Plainsboro High School North

McMahan Research Group

Over the past month, my group has worked on making our initial research question into one that can be a more specific design. Our initial question was to determine whether there is similarity between the entanglement of two or more particles over time (temporal non-locality) and distance (spatial non-locality).

After sharing over specific questions from each of our individual investigations, I found interesting the 'Quantum Field Theory'. In my initial information gathering for the old question, I discovered a new mechanism of sudden death and rebirth manifestations, which appeared as sine curve oscillations, as well as some asymptotic behavior regarding temporal entanglement.

The Quantum Field Theory has added more insight into my existing understanding. This particular theory believes that there is an hourglass figure (see below) that describes both past and future light cones. If the time duration is small, and the detectors of distance are outside of these cones, there is an observed oscillation between the two particles.

insert picture 1

[1] Quantum Field Theory

insert picture 2

[2] Spatial Distance and Amplitude Relationship

There is also a conjecture that the amplitude of the wave is dependent on the spatial distance. This agrees with the experimental proof as to why the points of the concurrence between the two particles have varying distances. Our group has completed the background research on this topic and is beginning to work on the research paper.

Exploring Spatial Entanglement through X-Entanglement and QFT

Contributed by Ananya Balaji

10th Grade, West Windsor-Plainsboro High School North **Grade: 11*

McMahan Research Group

With the first semester coming to an end, our group worked hard to compile our findings into the final research report. That said, we narrowed our paper to encompass Spatial Entanglement: the way by which physical properties of a particle changes by position in space. This was accomplished through two approaches.

The first method used experiments to detect X-entanglement between two entangled particles. X-entanglement is a spatio-temporal relation that follows a hyperbolic geometric relationship, as shown below. Current research has looked at the particles generated by SPDC, an optical effect where photons have either the same or perpendicular polarizations. We added another

layer. We desired to detect the effects of using Four-Wave Mixing, which uses the signals of various wavelengths to generate photons with multi-faceted movements. (add picture 1 here).
The second method looked into the Quantum Field Theory, which I've shared before. As a small recap, the QFT is represented as a solid hourglass figure that describes the past and future as cones. Detectors located outside this demonstration have an observed oscillation. Those located inside have regions of interference. In our research, we took an approach that uses a Tpx3Cam, a special device that compares the distance of photons and their relative strength. We corroborated the data gathered with that of outside resources, and received some suggestions of a correlation. (add picture 2 here).

Although our group would like to dive deeper into Quantum Entanglement, for this second semester, we want to look into Quantum Computing, to conduct individualized searches for data and a more hands-on process.
[1] https://arxiv.org/pdf/0812.3533.pdf
[2] https://www.worldscientific.com/doi/epdf/10.1142/S0219749919410272

Using Genetic Algorithms and Artificial Neural Networks to predict long term changes in healthcare stocks

Contributed by Samarth Boranna
10th Grade, Brangam
McMahan Research Group

Over the last few months, our group has worked towards predicting the movement of several healthcare related stocks, specifically, AZN, MRNA, BIIB, GILD, and PFE, through utilizing a Genetic Algorithm and an ANN (Artificial Neural Network) . We chose these stocks as they are all related in some way to Covid-19 and have a sufficient amount of historical data available. This is important as historic data is crucial in the training and testing of our Genetic Algorithm. In addition to historic data, our group decided to use investor sentiment as the main input in the algorithm.
In order to mimic investor sentiment, we decided to focus on tweets and news websites. Through creating and utilizing our sentiment code, we could twitter mine relevant accounts and go through popular news websites to derive a sentiment value between -1 and 1, allowing us to use this value as an input in our ANN.
In the last month, our group has coded an ANN in order to take in the historic data and sentiment value and return a prediction. We are working towards combining this ANN with the Genetic Algorithm in order to combat overfitting and fine-tune our prediction.

Predicting the Severity of a Covid Case

Contributed by Sarvagya Goyal
9th Grade, Dougherty Valley High School
McMahan Research Group

My group is using data to predict the severity of a COVID case. This month we have gathered more data from hospitals. We have contacted 50 hospitals and gotten 20 positive responses. We are also sorting and organizing the data and creating algorithms to examine it. Our plan is to create an algorithm that will accurately predict the severity of a Covid case from the symptoms that we get from our data. We will look at symptoms we get from data to determine this. Our result will be a number from 1-100 that determines this. Also we hope to have the data sorted and organized, and test the algorithm on the data before the end of the month. Next month we plan to verify the results of the algorithm and publish our algorithm and its results. We also hope to fix up our

algorithm and make it better, so that we get more accurate predictions.

Researching Clozapine and C. elegans in Schizophrenia Studies

Contributed by Isha Kale

10th Grade, American High School

Truong Research Group

Recently, our group has been working on maintaining our wild type C. elegans—quantifying worms, consistently transferring them to freshly seeded NGM plates, and recording the observations. We have also been learning more about clozapine, an atypical antipsychotic drug, which has a history in regarding schizophrenia, a common, psychotic disorder. Aside from keeping track of our worms, as for lab work, we have also begun a round two of the synchronization process. This procedure will allow us to work with worms when at the same developmental stages. This will especially be beneficial for when we start performing different assays on them in the future, with their development not being a factor of change.

Many of our group members have been contributing from home towards literature research, and writing protocols. One of our finalized protocols from this month is the “96-Well Developmental Delay and Lethality Assay" (Hao and Buttner, 2014). This protocol is specifically targeted towards using different concentrations of clozapine to find the optimal concentration which works for C. elegans. We also chose varying concentrations of clozapine, with predictions of optimal concentration to be around 150 ug/ml, based on prior research. Our group predicts that the CB1372 transgenic strain (with a mutation in its daf-7 gene, mostly affecting their social feeding) will show the most improvement in symptoms of immobility when experiencing optimal concentrations of clozapine. In a contrasting prediction, the wild type worms will start to exhibit unusual movements when reacting to clozapine.

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synchronization process. This procedure will allow us to work with worms when at the same developmental stages. This will especially be beneficial for when we start performing different assays on them in the future, with their development not being a factor of change.

Quantum Entanglement Dynamics in Relation to Spatial Distance

Contributed by Modakar Kurma
10th Grade, Quarry Lane School
McMahan Research Group

Quantum entanglement is the phenomenon where two particles are connected such that their properties are identical. Currently, the quantum mechanics research group is looking into how the spatial distance, or how far away the entangled particles are, affects the strength and the ability of two particles to become entangled. To achieve this, we will look at two different perspectives and see how these perspectives relate to each other.

Our first perspective will be a mathematical approach. Our mathematical approach is derived from Unruh DeWitt detectors, hypothetical detectors that can become entangled in various points in space and time. The math that arises from these detectors provides valuable insights. The most important insight is the fact that the strength of entanglement seems not to have a possible correlation with the spatial distance, as when the spatial distance increases, the strength of entanglement may increase or decrease at different moments in time. On the other hand, when the detectors are extremely close by, there still seems to be residual entanglement remaining after disentanglement [1]. This suggests that a temporal aspect (entanglement through time) may play a larger role when considering entanglement dynamics.

Our second perspective will come from a more experimental approach, where we will use data from an actual quantum entanglement experiment. We have found universities and research institutions that conduct quantum entanglement experiments that measure the entanglement dynamics as a function of the spatial distance between the entangled particles [2]. We will use this data, in conjunction with the mathematical approach, to give us a better understanding of how the distance between two entangled particles works from a Quantum Field Theory perspective.

[1] https://arxiv.org/pdf/0812.4391v2.pdf
[2] https://www.worldscientific.com/doi/epdf/10.1142/S0219749919410272

Investigating the Relationship Between Water and Nitrogen Content in Native Grasses and Invasive Bromes and Wildfires in California

Contributed by Mohika Pandey
10th Grade, Irvington High School
Suresh Research Group

Over the course of this past month, the nitrogen subgroup in the Wildfire and Climate Change Group has conducted soil testing on all three trials of grasses. In December, we tested the soil of these plants that have been growing for 3 to 4 weeks to determine their initial nitrogen content. After we extracted the soil and conducted the necessary steps, we waited for the solution in a test tube to change to a specific shade of a pink color based on the level of nitrogen in the soil. After testing the soil of all of our plants, and a batch of sterilized soil, we found that the shade of the solutions were a very light shade of pink, indicating that there was little to no nitrogen present in the soil. These results don't seem reasonable, since our grasses are growing successfully, so they must have generated at least

some nitrogen. So for this reason, we have decided to test the soil of these plants once more with a different testing kit before we continue on with our experiment. We suspect that the cause of our results may be because of the type of soil testing kit, as it only requires us to incubate the solution for five minutes, but the soil may need to incubate for a longer time. Another cause of our results may also be that we did not shake our test tubes well enough for the soil to properly mix in with the solution.

Modeling Alzheimer's Disease in Genetically Modified Caenorhabditis Elegan Strains

Contributed by Tanvi Sri Sai Penugonda
10th Grade, Granada High School
Truong Research Group

Alzheimers is a disease which is caused by the aggregation of amyloid beta in the brain. To study this phenomenon, we are using Caenorhabditis elegans (C. elegans) for our research as they contain the APP-like gene(apl-1), tau homolog (ptl-1), and presenilin-like genes (sel-12 and hop-1) that have been found to be responsible for the onset of Alzheimer's disease.

This month, our group has been preparing to assess short term and long term associative memory formation and duration in our transgenic C. elegan models. In N2 WT worms, short term associative memory (STAM) typically lasts for 2 hours while long term associative memory (LTAM) can last up to 24 hours. So far, we have been working on transferring C. elegans onto E. Coli OP50 seeded NGM plates, classifying the C. elegans based on their larval stages, and performing synchronization of the transgenic strains. We have also started to perform chemotaxis assays on the N2 WT worms to evaluate their baseline levels of associative memory when exposed to butanol in the absence of food. We hypothesize that the presence of amyloid beta in neurons and muscle cells will weaken the formation and duration of the associative memory, possibly due to cell damage or death. We hypothesize that the CL2355 strain will have the greatest decrease in STAM and LTAM duration than all of the other strains since it contains Aβ in the neurons, which are most directly related to memory formation. In the CL2122 strain, we hypothesize that STAM and LTAM will not have a significant decrease, as muscle cells are not directly linked to memory formation. In the CL2120 strain, we hypothesize that their STAM and LTAM will also not significantly be lessened since the CL2120 strain and the previous strain are genetically analogous to each other but CL2120 doesn't express Aβ.

Screening of various natural bio-enhancers using a model drug

Contributed by Destiny Pinto
10th Grade, Dougherty Valley High School
Renganathan Research Group

(Contributed by Destiny Pinto, Tanusree Banerjee, Anvita Das, Tejasvi Hariharan, Riya Ubale, and Avi Uppalapati) Bioavailability is the amount of drug from the initial dosage that reaches the drug's target site or the systemic circulation. Many drugs have low oral bioavailability, and as a result, large doses are required for optimal pharmacological effects. This makes drugs more expensive. In our research, we aim to use natural products found in plants to increase the bioavailability of a model drug as well as study the mechanisms they use to do this. These natural substances are known as bio-enhancers, which increase the bioavailability and bioefficacy of other active substances with which they are combined.

Most drugs that are taken orally have to go through the gastrointestinal system for intestinal absorption, where first pass metabolism and the metabolizing enzymes within the liver decrease

their bioavailability. In the gastrointestinal tract, drugs must penetrate the intestinal epithelial cells, which have a lipid-like barrier, causing many drugs to have poor permeation characteristics. Additionally, the transporter P-glycoprotein (P-gp) can reduce the bioavailability of the drug through an efflux mechanism. Bio-enhancers address this problem by increasing the quantity of the drug that appears in the systemic blood circulation by modulating membrane permeation and/or pre-systemic metabolism in various ways.

Key characteristics of bio-enhancers include nontoxicity to humans and animals, effective at a very low concentration in a combination, easy to formulate, and most importantly, enhance the absorption of the drug.

Dielectric Properties of Cancerous and Healthy Tissue

Contributed by Pranav Prakash

10th Grade, Mission San Jose High School

Dani Research Group

As part of Dr. Asmita Dani's research group, we have focused our research on using microwave and millimeter-wave radio frequency to measure the dielectric properties of plants and human tissue. Cancer is a common fatal disease that kills more than 606,520 people in the United States alone. To identify various cancer in the body, scientists have used the dielectric properties of healthy human tissue and correlated the measurements to types of cancerous tissues. Our group intends to use radio frequency technology to measure the dielectric properties of both types of tissue and to possibly provide a source of data as to how the tissues differ. We also hope to find an extensive explanation as to why the measurements differ between cancerous tissue and healthy tissue.

One of the projects that my group is conducting relates to the use of a network analyzer and open-ended coaxial probe to measure the dielectric constant of human and plant matter. Dielectric constant defines the electrical properties of a material based on the amount of electrical fields that can propagate through the material. We will be testing two human tissue strains to collect the dielectric properties between 200 megahertz (MHz) to 5 gigahertz(GHz). Each tissue sample will be used to find the difference between measurements for cancerous and noncancerous cells along with a correlation between the frequency and dielectric constant.

Synthesis and Characterization of Benzimidazole Derivatives as Potential KRAS Inhibitors

Contributed by Pratyush Singh

10th Grade, American High School

Clark Research Group

KRAS is an important protein that plays a role in cell differentiation, proliferation, and apoptosis, and belongs to a class of oncogenes, which when mutated, can contribute to the growth of cancerous tumors. KRAS was previously thought to be undruggable, but recent discoveries show that benzimidazole derivatives, such as the ones we are synthesizing do have an inhibiting effect on the gene. During the course of the ASDRP semester our group has synthesized various derivatives that hold inhibiting effects on KRAS with the purpose of finding the most optimal inhibitor for the protein out of the ones that were selectively docked by the Brah group, who we are

working in conjunction with. In the recent month our work is drawing close to a temporary conclusion, as we have nearly reached completion in compounds C and D. Furthermore compounds E, F, and G are expected to reach completion by the end of December. Our work was inhibited by medical issues, and issues with TLC's, but our work has been successful as a whole. [Attached below is a copy of the NMR scan of compound D.]

Investigating the Effect of Curcumin on Alpha-synuclein Aggregations in an E.coli model

Contributed by Arushi Singhal

10th Grade, Leigh High School

Truong Research Group

Parkinson's Disease is a neurodegenerative disorder that limits movement, caused by aggregations of alpha-synuclein in the brain. Our group is collaborating with Mr. Njoo's group to synthesize curcumin analogs to assess its effectiveness in treating the toxic aggregations of alpha-synuclein in E.coli cells.

The curcumin analogs are created using vanillin, a compound similar to curcumin in regards to its structure and beneficial properties (anti-oxidative and anti-inflammatory). Based on its cLogP values, a measure of hydrophilicity, we can hypothesize which analog will be more effective against alpha-synuclein aggregation in our E. coli cell model by comparing them to curcumin.

This past month, we have synthesized and purified the analogs.We have also begun to establish our E.coli cell model by isolating the pT7-7 plasmid expressing alpha-synuclein.

In the next few weeks, our group will continue to collaborate with Mr. Njoo's group to create curcumin analogs and to understand their individual differences and specific properties in comparison to curcumin to determine its effectiveness in our cell model. We will also be performing bacterial transformations and restriction digests of the pT7-7 plasmid to verify the integrity of the plasmid within the cell.

Alzheimer's Disease in Genetically Modified Caenorhabditis Elegans Strains

Contributed by Simran Tawari

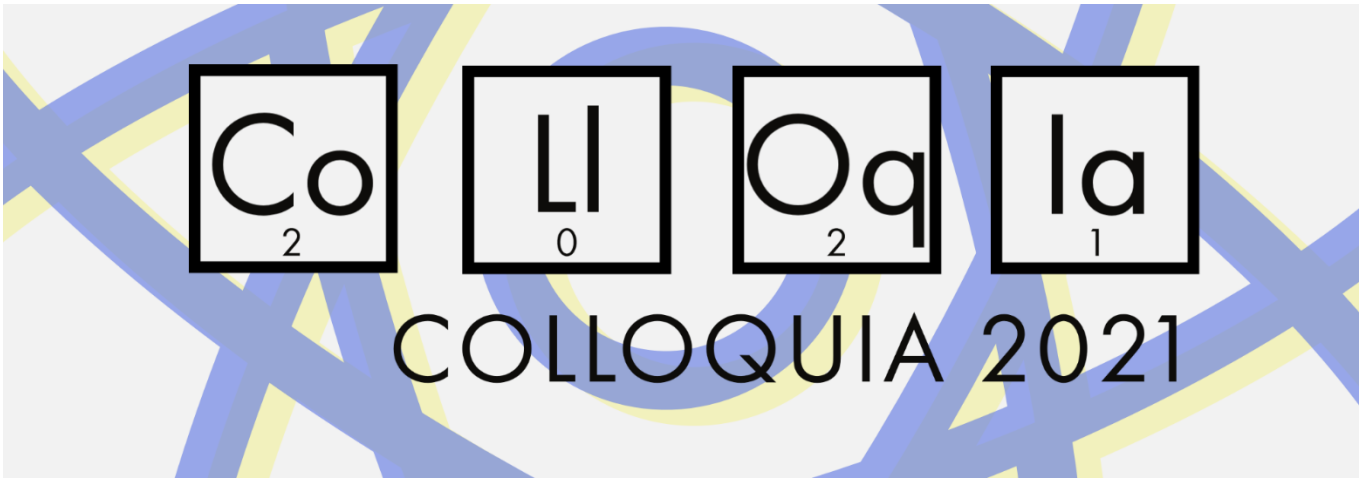
10th Grade, American High School

Truong Research Group

Alzheimer's Disease is characterized by the formation of amyloid beta plaques. To study the effects of amyloid beta aggregation, we are using Caenorhabditis elegans, also known as C. elegans because they contain APP-like genes(apl-1), tau homolog(ptl-1), and presenilin-like genes(sel-12 and hop-1).

This month we have been preparing to test the associative memory of C. elegans through chemotaxis, short term associative assay (STAM), and long term associative assay(LTAM). In the chemotaxis assay we performed, the C. elegans were starved and then given food in the presence of butanol. The C. elegans form a positive association between the food and butanol and this associative memory is tested to understand the effects of amyloid beta aggregation on different transgenic strains. N2WT C. elegans do not display amyloid beta aggregation and have a short term associative memory(STAM) of around two hours and a long term associative assay(LTAM) for around twenty-four hours. We are also testing the CL2122 strain which has amyloid beta aggregation in the muscle cells, the CL2120 strain which is genetically analogous to CL2122 but does not express amyloid beta, and the CL2355 strain which has aggregation of amyloid beta in its neurons. We hypothesize that amyloid beta aggregation in the neurons will significantly

reduce the duration of associative memory and affect mobility.



Every week, some of our senior researchers in each department at ASDRP give public seminars presenting the current state of the field, and disseminating how their research at ASDRP fits into the broader context of the frontiers of modern science and engineering. Colloquia are public events, and anyone can join. Click here for the latest Colloquia Information and Presenters.

January

Arti S., Quarry Lane School
Njoo Research Group Organic, Medicinal Chemistry
Green Approaches to and virtual hit-to-lead generation of synthetic monoterpenoid nonucleoside reverse transcriptase inhibitors towards the development of novel HIV antiretroviral therapies

Modakar K., Quarry Lane School
Diptanshu S., BASIS Independent H.S., Ananya B., W. Windsor Plainsboro HS N., McMahan Research Group, Quantum Physics
Use of Unruh DeWitt Detectors and Tpx3Cam to understand Spatial Entanglement from a Quantum Field Theory Perspective.

Shreya L., Dougherty Valley High School
Suresh Research Group Genetics, Environmental Science
Exploring the Potential Allergens in Dimocarpus longan

Amelyn P., Dublin High School,
Njoo Research Group, Organic, Medicinal Chemistry
Development of Novel Dihydropyridine Inhibitors of Kinesin Eg5 as Potential Anti-Cancer Agents

Rhea S., American High School
Downing Research Group, Machine Learning, Data Science
A Proposed Mapping of the Voynich Alphabet to an Indo-European Language and new Findings Concerning Sanskrit and Arabic Languages.

Srideep D., Irvington High School
Downing Research Group, Machine Learning, Data Science
Application of Data Mining and Associative Learning to Search For Potentially Habitable Exoplanets.

Krithikaa P., Doughtery Valley High School
Njoo Research Group, Organic, Medicinal Chemistry
Synthetic versatility of β-ketoesters: Multicomponent Biginelli cyclocondensation reactions provide inroads for rapid access to privileged scaffolds in medicinal chemistry for anti-cancer drug discovery.

Sophie P., Carlmont High School
Njoo Research Group, Organic, Medicinal Chemistry
Comparative singlet oxygen photosensitizer efficiency of berberine, rose bengal, and methylene blue by time course nuclear magnetic resonance (NMR) monitoring of a photochemical 4+2 cycloaddition endoperoxide formation.

February

Dhruv K., BASIS Independent High School
Tallapaka Research Group, Biochemistry
Effects of Curcumin On Known Protein Interactions in Human Cell Lines.

Ayeeshi P., Mission San Jose High School
Njoo Research Group, Organic, Medicinal Chemistry

Semi-synthesis of penicillin-type analogs and β-lactam antibiotics and structure-activity relationship of N-acyl β-lactam broad-spectrum antibiotics.

Vajraang P. & Aaryan R., Irvington High School
Subramaniam Research Group, Data Science
Fake Review Detection with Machine Learning.

Gia O., Granada High School
Truong Research Group, Molecular & Cell Biology
Evaluating the Effectiveness of Clozapine on Schizophrenic C. elegan Models.

Charissa L., Bishop O'Dowd High School
Njoo Research Group, Organic, Medicinal Chemistry
In silico_ screening of a library of carmofur analogs as potential inhibitors of the SARS-CoV-2 main protease and mutational analysis studies of Mpro and HIV-1 reverse transcriptase.

Nikhail J., Fremont High School
Patel Research Group, Inorganic Chemistry & Materials Science
Nickel nanoparticle synthesis for use in catalysts in oxygen reduction reaction.

Jackie L., BASIS Indepedent High School
McMahan Research Group, Quantum Physics
Predicting the severity of individual coronavirus cases given demographics and pre-existing conditions.

Erin Y., Mission San Jose High School
Suresh Research Group, Genetics, Environmental Science
Impacts of auxin therapy alongside abiotic stress on the phenolic content of Mentha × piperita and implications towards ameliorating Alzheimer's disease.

Karthikha I., Mission San Jose High School
Njoo Research Group, Organic, Medicinal Chemistry
Photobiological activity of berberine and semi-synthetic analogs.

Christopher C., The King's Academy, Dani Research Group, Microwave Physics
Planar antennas for Passive radiometric measurements.