ASPIRE

ASDRP
Aspiring Scholars Directed Research Program

A researcher newsletter of the Aspiring Scholars Directed Research Program

November 1, 2020

Announcements

Grand Opening of the Remodeled ASDRP Engineering R&D Laboratory Building
We are excited to unveil the newest additions to the ASDRP campus in Warm Springs, CA. The new Engineering building houses both high-performance server clusters (Linux and Windows Environments), all ASDRP 3D printers / laser cutters, a new Thermo Scientific iCAP 7000 Inductively Coupled Plasma Optical Emission Spectrometer, our NuVant Potentiostat, our Thermo Nilton X-Ray fluorescence spectrometer, an environmental engineering corner, and the latest equipment upgrades for mechanical, chemical, and electrical engineering. The newly-renovated Engineering center sits adjacent to our Life Sciences Laboratory and provides state-of-the-art scientific capabilities to our high school researchers.

LEAF

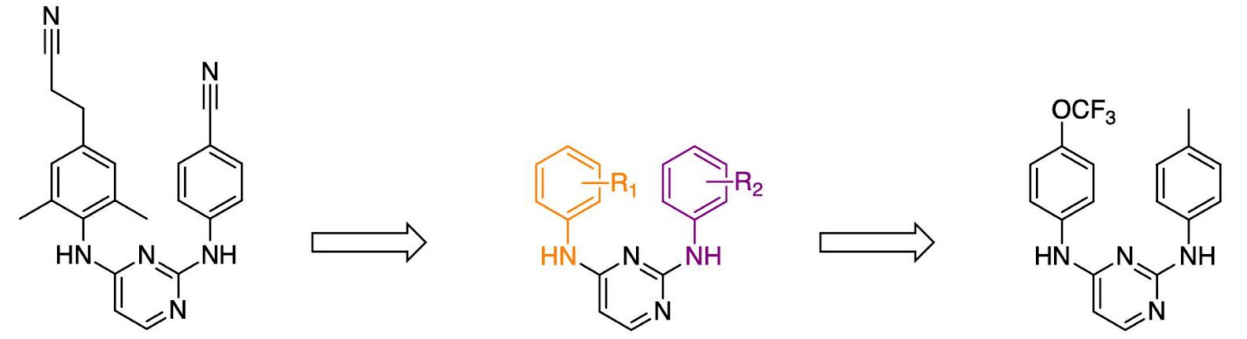
ASDRP Partners with Fremont LEAF
ASDRP is proud to begin a collaboration with Fremont LEAF (Local Ecology and Agriculture in Fremont), a local nonprofit that runs several community garden and urban agriculture sites in the area. The collaboration involves seven ASDRP investigators, across all three departments, and is spearheaded by Soumya Suresh and the Biology Department. Researchers at ASDRP working on the collaboration will be developing methodology for sustainable urban agriculture, analyzing microbiomes and soil pollutants, and developing remote instrumentation for collecting environmental data such as pH, humidity, etc.

Bi-Weekly Parent Fireside Chat
Join us every other Wednesday evening for our parent call! The ASDRP leadership board spends an hour every other week connecting with our parents and helping them understand expectations and giving the latest updates.

October Publication Spotlight

"Design and *in silico* screening of analogs of rilpivirine as novel non-nucleoside reverse transcriptase inhibitors (NNRTIs) for antiretroviral therapy"

by Jeslyn Wu, Charissa Luk, Catherine Zhou, Aashi Shah, Aishwarya Yuvaraj, *Edward Njoo*



Rilpivirine
Second-generation NNRTI

N,N-diarylpyrimidine-2,4-diamine
Designed novel analogs with potential NNRTI activity

Identified hit analog

Jeslyn Wu (11, Mission San Jose), **Charissa Luk** (11, Bishop O'Dowd), **Catherine Zhou** (10, Lynbrook), **Aashi Shah** (10, Amador Valley), and **Aishwarya Yuvaraj** (11, American) are student researchers in the Njoo research group in the Chemistry Department at ASDRP, where they work as part of a team of student researchers in heart of medicinal chemistry & drug discovery. Over the last several months, Jeslyn and co-workers have been hard at work using both computational tools and chemical synthesis towards development of next-generation antiretroviral small molecules to combat the human immunodeficiency virus (HIV). This month, the group submitted their latest manuscript for peer-review and reported the results of an aggressive high-throughput virtual screening campaign, which identified several hit structures as potential next-generation antiretroviral therapeutics. The results from this initial study provide the basis for future plans in chemical synthesis. Read the group's preprint here.

Part of the retroviral genus, the human immunodeficiency virus (HIV) relies on their host's cellular machinery for replication. The virus's genetic material is stored in ribonucleic acid (RNA) which, upon delivery into the host, is reverse transcribed into DNA by the enzyme reverse transcriptase (RT), which is then used for production of new viral components, thus allowing for further replication and spread. Because HIV selectively targets CD4+ T cells in the host's immune system, the infection inevitably leads to weakening of the host's immune system, which can then lead to acquired immunodeficiency syndrome (AIDs). One treatment for HIV are non-nucleoside reverse transcriptase inhibitors (NNRTIs), which are allosteric inhibitors of RT that disable the enzyme's activity and thus viral replication. Previous NNRTIs developed and approved for clinical use by the FDA include etravirine, doravirine, and rilpivirine. However, resistance of RT through mutations necessitates the continued development ofNNRTIs. Here, the structure of rilpivirine, a relatively recently FDA approved NNRTI, was used to design a library of analogs that were then evaluated in silico via high throughput virtual screening (HTVS). From this, several hit structures were identified as potential next-generation NNRTIs with comparable predicted binding affinities to the allosteric binding pocket in RT as rilpivirine.

Student Research Updates

Heterologous expression of alpha synuclein, an amyloidogenic protein linked to Parkinson's disease.

*Contributed by **Amulya Harish**, 10th Grade, Truong Research Group*

In Ms. Carly Truong's Parkinson's disease group, my group has been researching the role of alpha-synuclein in Parkinson's Disease. We have also been exploring the effectiveness of curcumin as a treatment for alpha-synuclein aggregation. We have started going into the lab to start culturing our plasmid.The purpose of this experiment is to purify the plasmid DNA in order to successfully introduce it into our bacterial cell model.

In our research, we found that alpha-synuclein forms Lewy bodies on top of dopaminergic neurons in Parkinson's disease patients. Dopaminergic neurons are essential to producing dopamine in the brain. Alpha-synuclein damages these neurons through various methods, including damaging mitochondrial structures and altering the cytoskeletons of cells by damaging the stability of microtubules. While monomers and fibrils are non toxic, alpha-synuclein oligomers increase cellular toxicity.

Currently, scientists are exploring the use of curcumin in targeting alpha-synuclein oligomers.. Curcumin is a compound that is commonly found in turmeric spice that is used in Asian cuisine. It is a polyphenol, which means that it has two or more phenol rings in its structure. Because of its structure, it has been observed to bind to the hydrophobic surfaces of alpha-synuclein oligomers and fibrils, reduce their toxicities, and increase cell viability.

We hope to test the viability of curcumin as a potential Parkinson's disease treatment this fall!

Using Genetic Algorithms to model long-term stock market trends

*Contributed by **Akash Iyer**, 10th Grade, McMahan Research Group*

Imagine a world without Google Maps. What will the traffic be like? What route should you take? Now, Imagine a life without weather forecasts. Should you take an umbrella tomorrow or wear sunscreen? Should you take a jacket? What if you didn't have Spotify? How will you find your new favorite song? People value predictability and routine in their daily life. Over the years, advances in technology have predicted many things, from small things like spotify playlists and ETA's, to larger things like natural disasters.

Most prediction algorithms are based on inputting various factors that affect the outcome, and models are generated with weights and biases for all known factors. Most models use machine learning techniques, such as Particle Swarm Optimization, Genetic Algorithms, and Support Vector Machines. One of the biggest opportunities for prediction algorithms is the infamous stock market. Its volatility and unpredictability is perfect to train special machine learning algorithms to find patterns that no human can spot. A genetic algorithm is our model of choice when trying to tackle this beast.

We scoured the scientific landscape for others attempting a similar thing, but none of the articles have focused on predicting the long-term stock market. Therefore we have drafted a research proposal to use genetic algorithms to fill this very obvious gap. Almost done with our first draft, we're entering the editing phase very shortly and plan on commencing our research within the next two weeks. We've also brainstormed several factors that move the stock market and are currently learning the programming languages that will aid us in our research.

Modeling Alzheimer's Disease in Genetically Modified *Caenorhabitis elegans* strains

*Contributed by **Deelena Ghosh**, 10th Grade, Truong Research Group*

Alzheimer's disease is a progressive neurodegenerative disease. Over the last few weeks, my subgroup has been reviewing literature to understand how amyloid beta aggregation affects memory formation and disease progression. Our research will be using transgenic C. elegan models to study the effect of amyloid beta in short and long term memory formation. C. elegans are small transparent roundworms that have shared a common ancestor with humans hundreds of millions of years ago.

We are also researching the procedures necessary for assessing associative memory in C. elegans and the effect of amyloid beta aggregation. C. elegans rely on their associative memory to survive by recalling information regarding food source or navigation. In the lab, we are practicing our techniques for transferring, growing and maintaining wild type C. elegans, as well as classifying them according to their life cycle (see image below).

Currently, we are working on synchronization, a technique that harvests the eggs in order to ensure the next generation grows at relatively the same rate.

Quantum Entanglement and Relation to Spatial and Temporal Nonlocality

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

Quantum entanglement was described by Einstein as the "spooky action at a distance". Quantum entanglement is the property when two particles can be connected such that they share the same properties and one particle cannot be defined independently of the other. Some of the properties of the particles such as spin, momentum, and polarization can be said to be identical. This unique phenomenon raises many questions, such as, "Can information travel faster than the speed of light and therefore violate the theory of relativity (also known as the EPR Paradox)?" For example, if we have two particles (A and B) that are entangled, and we measure the spin of particle A, we would instantaneously also know the spin of particle B, thus allowing information to travel faster than the speed of light.

This led our group to the property of nonlocality (the idea where there is no principle of position or distance), more specifically, temporal and spatial nonlocality. Much of the work that has been currently done in the field of entanglement has been in spatial entanglement. Therefore, we intend to pursue research to find a more universal theory that encompasses both space and time nonlocality and its relation to Quantum Entanglement.

October Article from the COVID-19 Research Group

*Contributed by **Sireesh Pedapenki**, 9th Grade, Washington High School, McMahan Research Group*

My group and I are conducting research on the COVID-19 pandemic, guided by our advisor, Dr.McMahan. We are hoping to develop a tool that could predict the severity of COVID-19 in an individual. This month, we worked on a research proposal on Google Slides. In the proposal, we included some background information on

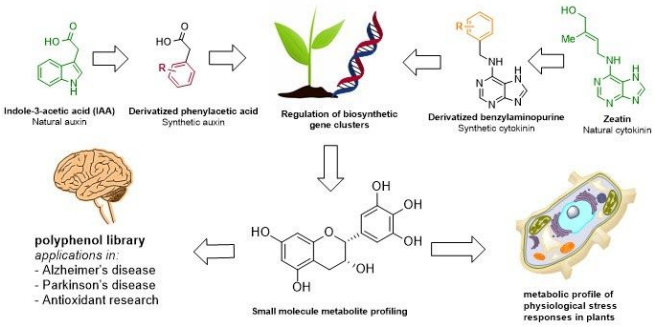
COVID-19 and some details of previous studies and other research. We also included some ideas as to how to make previous research on the topic better (look into pre-existing conditions, etc.). The importance of our research and the possible impact on the field was also included. Right now, we are trying to gather more specific data, such as underlying diseases like diabetes. Currently, we are emailing both local and national hospitals to gather as much data as we can for our algorithm. We are still waiting for responses from the hospitals we already emailed. We were able to get a lot done this month and hopefully, we are able to do as much or more next month!

Synthesis and Testing of Plant Hormone Analogs

*Contributed by **Shreya Anand**, 10th Grade, Los Altos High School, Njoo Research Group*

In science, we are almost always told that no field can be considered separate; everything is intertwined and equally as important. Over the past few months of research, the Njoo plant hormones subgroup has realized this by collaborating with the Suresh biology group. For some background: plant hormones are naturally occurring chemicals that promote cell growth in plants. Plants produce these hormones in varying amounts to help regulate and support crucial functions within the plant. Our group aims to synthesize analogs of such compounds and test them on plants to understand their effects.

The importance of this study is that certain plant hormones have been shown to reduce the effects of neurodegenerative diseases such as Alzheimer's and Parkinson's, so their synthesis is a very important area of research medically. As the chemists of this collaboration, we synthesize and purify our compounds. Initially, over the summer, we were also growing our own plants and testing them as well. They were all unfortunately unsuccessful attempts, and we soon realized that we needed a collaboration to ensure that the biology aspect would be well represented and executed in our project.



Over these past few months, we have accomplished a lot: we've synthesized new hormones to test, we've started growing new plants (which are actually alive!), and most importantly, we've learned the value of a team effort, especially in science. We hope to continue our synthesis and testing methods while expanding our knowledge of plant hormones and possible synthetic routes. And we're looking forward to facing all of the challenges ahead.

Microwave and millimeter wave radio frequency (RF) technology and sensors

*Contributed by **Pranav Prakash**, 10th Grade, Mission San Jose High School, Dani Research Group*

As part of Dr. Asmita Dani's research group, we are centering our research around the use of microwave and millimeter wave radio frequency (RF) technology and sensors to measure the water content and biological effects in plant and human matter. Climate change and population explosion has proven to have drastic effects on the agricultural industry, as there are many droughts and water shortages, limiting crop harvests. Farmers struggle with controlling water uptake in practical ways, which leads to crop damage.

Our team is trying to remote sensing technologies to remotely monitor water content in smaller scale crop production, possibly to help develop a larger scale technology to address this crisis. Our group is also working on reducing the dependence on artificial chemical fertilizers to get crop yield by instead exploring microwave and millimeter wave radiation as a potential crop health enhancement method with extremely low and safe radiation levels.

One of the projects my team is researching is on the biological effect of using millimeter wave (MMW)electromagnetic fields on germination and plant growth. We will be testing many biological mediums, including grains and fungi to understand how to manipulate plant growth and biological parameters by exposing them to low intensity RF power, along with testing how to remotely measure water content of the samples with remote sensing radiometry. Each sample will undergo exposure to a specific radiofrequency, ranging from 5Hz to 20GHz, as well as a specific duration of exposure, ranging from 1 minute to an hour depending on the frequency. Each sample will be tested for changes in DNA, germination, seed weight and length, protein denaturing and production, enzyme production and water content. We hope to not only discover the effects of MMW exposure on multiple seed and plant mediums, but a way to effectively detect changes in water content remotely for these samples as well.

Uncovering the Underlying Genetics of Schizophrenia with Transgenic C. elegans

*Contributed by **Alisha Shah**, 10th Grade, Mission Irvington High School, Truong Research Group*

Our group is assessing the underlying genetics of schizophrenia using transgenic C. elegans, a species of roundworm. Schizophrenia is characterized by the dissociation from reality with symptoms including hallucinations, reduced motivation, etc. ("Schizophrenia," 2020). Different strains of C. elegans have genetic mutations resulting in specific behaviors, including solitary feeding and immobility, which correlate to the symptoms seen in schizophrenia, such as social withdrawal and lack of motivation.

We have learned that these worms typically partake in social feeding, which is defined as the aggregation around food. However, specific mutations cause the worms to be a solitary feeder. The second behavior is immobility, in which the worms become suicidal by overriding their instincts to remain in the same location until they die (Dwyer, 2018). Currently, our group is learning how to move, grow, and maintain wild type C. elegans. We transferred C. elegans to fresh NGM agar plates seeded with E. coli OP50, a bacterial strain used as food for the worms. After they have reached the adult stage, we performed synchronization, a procedure involving killing the adult worms but leaving the eggs so the next generation of worms will grow at relatively the same rate.

Unfortunately, a few days after synchronizing, our group noticed that the worms were not moving and looked very unhealthy. Going forward, my labmates and I plan on repeating synchronization on the practice worms to become proficient before working with transgenic C. elegan strains.

Student Colloquia

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.

September | October

Department of Biological, Human & Life Sciences

Chandraki Chatterjee | 12th grade | **Dougherty Valley High School** | Tallapaka Research Group
Efficacy of Novel Monastrol Analogs: Testing Cell Viability in Known Chemotherapeutics
Keywords: Monastrol | Mitosis | Bioactivity | Kinesin | Chemotherapeutics

Aarav Dubey | 12th grade | **Maria Carillo High School** | Suresh Research Group
Testing a novel DNA-directed interfering RNA fragment to treat SARS-CoV-2
Keywords: Gene-silencing | biotechnology | SARS-CoV-2 | ddRNAi technology

Sophia Fung | 11th grade | **Dougherty Valley High School** | Tallapaka Research Group
Development of novel acrylonitrile inhibitors of TP53 Induced Glycolysis Regulatory Phosphatase (TIGAR) as a strategy for modulation of the p53 tumor suppressor pathway in anticancer therapy
Keywords: TP53-Induced Glycolysis and Apoptosis Regulator (TIGAR) | Enzyme Kinetics | Cancer| Acrylonitrile Inhibitors | Discontinuous Assay

Allen Ni | 12th grade | **BASIS Independent Silicon Valley** | Truong Research Group
Investigating the effect of curcumin on alpha synuclein aggregation in an in vitro testing system using E. coli for expression
Keywords: Alpha Synuclein | Parkinson's Disease | Lewy Bodies | Bacterial Transformation | Curcumin

Tharika Thambidurai | 12th grade | **BASIS Independent Silicon Valley** | Suresh Research Group
Reducing Air Pollution From Wildfires Using Self-Cleaning Photocatalyst
Keywords: Environmental Science | Photocatalysis | Wildfires | Air pollution

Department of Chemistry, Biochemistry & Physics

Bhavesh Ashok | 12th grade | **Amador Valley High School** | Brah Research Group
Applied computational biochemistry in the research, development and synthesis of bioactive compounds
Keywords: Computational Biochemistry | MM/QM | HTVS | Molecular Dynamics | Medicinal Chemistry

Asavari Gowda | 12th grade | Mission San Jose High School | Njoo Research Group
Development of Novel Anti-Cancer Ligands through G-Quadruplex Stabilization and Inhibition of the TP53-Inducible Glycolysis and Apoptosis Regulator
Keywords: G-Quadruplex | Telomerase | Telomere | TP53-Induced Glycolysis and Apoptosis Regulator (TIGAR) | Cancer | Acrylonitrile Inhibitors Enzyme Kinetics | Density Functional Theory (DFT)

Shivani Manivasagan | 12th grade | Irvington High School | Patel Research Group
Using Functionalized Graphene Quantum Dots (GQDs) as Dye Materials to Optimize Dye-Sensitized Solar Cells (DSSCs)
Keywords: Solar energy | dye-sensitized sola | cells | graphene quantum dots | N-GQDs | S,N-GQDs | Materials Science

Pranjal Verma | 12th grade | Dougherty Valley High School | Njoo Research Group
In vivo screening of halobenzoyl and acyl beta-lactam analogs and structure-activity relationship of beta-lactam containing antibiotics and bacterial penicillin binding proteins
Keywords: Antibiotics | Beta lactams | Organic Chemistry

Anushka Wagle | 12th grade | Fremont High School | Renganathan Research Group
Studying the Therapeutic Potential of Natural Products against Diabetes Mellitus on C. elegans model.
Key Words: Diabetes Mellitus | insulin resistance | natural products | Caenorhabditis elegans

Department of Computer Science & Engineering

Debut: ASDRP Engineering Research & Development Laboratory

Chandraki Chatterjee | 12th grade | Dougherty Valley High School | Tallapaka Research Group
Efficacy of Novel Monastrol Analogs: Testing Cell Viability in Known Chemotherapeutics
Keywords: Monastrol | Mitosis | Bioactivity | Kinesin | Chemotherapeutics

Aditya Iyengar | 11th grade | Washington High School | Mui Research Group
Demographic Bias in Unemployment Across the U.S. during the 2020 COVID-19 Pandemic.
Keywords: Coronavirus, COVID-19 | Demographic Bias | K-means | Matplotlib | Python | Unemployment

Ojasw Upadhyay | 12th grade | American High School | Downing Research Group
A Proposed Mapping of the Voynich Alphabet to an Indo-European Language
Keywords: Voynich Manuscript | Romance Languages | Medieval Plants | Natural Language Processing

Hrithik Pai | 11th grade | Amador Valley High School | Downing Research Group
Application of Data Mining to Search for Potentially Habitable Exoplanets
Keywords: Habitable Zone | Habitable Exoplanets | Orbital Period | Density | Sustainable Atmosphere