Ionized and Molecular Gas in IC 860: Evidence for an Outflow
Carson Adams
Mentors: Katherine Alatalo and Anne M. Medling

Galaxies at present-day fall predominantly in two distinct populations, as either blue, star-forming spirals or red, quiescent early-type galaxies. Blue galaxies appear to evolve onto the red sequence as star formation is quenched. The absence of a significant population falling in the intermediate 'green valley' implies that these transitions must occur rapidly. Identifying the initial properties of and pathways taken by these ‘dying galaxies’ is essential to building a complete understanding of galactic evolution. In this work, we investigate these phenomena in action within IC 860 — a nearby, early-type spiral in the initial stages of undergoing a rapid transition in the presence of a powerful AGN-driven molecular outflow. As a shocked, post-starburst galaxy with an intermediate-age stellar population which lies on the blue end of the green valley, IC 860 provides a window into the early stages of galaxy transition and AGN feedback. We present Hubble Space Telescope imaging of IC 860 showing a violent, dusty outflow originating from a compact core. We find that the mean velocity map of the CO(1-0) from CARMA suggests a dynamically excited bar funneling molecular gas into the galactic center. Finally, we present kinematic maps of ionized gas emission lines as well as sodium D absorption tracing neutral winds obtained by the Wide-Field Spectrograph.

The Effect of Oncogenic APC Truncations on β-Catenin Levels
David M. Berger Maneiro
Mentor: Lea Goentoro

Adenomatous Polyposis Coli (APC) is a prominent tumor-suppressor gene involved in cell-cycle inhibition and WNT signaling. It has been well known for several years now that truncations in APC are highly correlated with colorectal cancer formation, especially in hotspots that remove β-Catenin binding sites and aid in destruction complex formation; over 60% of colorectal cancers present one of these truncations. Increased levels of β-Catenin have also been shown to increase the risk of colorectal cancer, indicating a close interplay between APC and β-Catenin in oncogenesis. We induced some of these truncations in APC to quantify how they change β-Catenin levels from the normal in an effort to better understand β-Catenin signaling changes in these cancers.

Identifying Orthogonal Nuclear Inclusion A Proteases in the Potyvirus Genus
Tatiana Brailovskaya
Mentors: Bil Clemons and Shyam Saladi

A large set of orthogonal proteases (i.e. proteases having highly distinct substrate specificities) that are easy to manipulate experimentally constitute a desirable toolkit for synthetic biology. Nuclear Inclusion A Proteases and their target sequences from the Potyvirus genus of (+)ssRNA viruses form an attractive group from which to find such proteases. We develop bioinformatics techniques for finding sets of mutually orthogonal proteases based on analysis of target cleavage site sequences. We devise a motif distance metric that can be used to compare cleavage sites from different proteases and a subsequent clustering procedure for identifying maximally distant sets of sites. Additionally, we propose a Markov Chain Monte Carlo simulation scheme to find proteases with maximally distinct cleavage sites, as quantified by the silhouette score. We further verify our bioinformatics predictions with free energy calculations that estimate binding affinities between protease and cleavage sites. Finally, we will experimentally test pairs of proteases in our final prediction for orthogonality. Next, these proteases will be used to build in vivo genetic circuits, however the methods developed here can have implications in other problems in computational biology such as identifying leucine zipper and other dimerization domain specificities.

Experimentally Determining the Dynamics of Jupiter’s Polar Vortices
Jackson Briones
Mentors: Andrew P. Ingersoll and Cheng Li

On the Cassini space mission, two vortex configurations were observed at Jupiter’s poles; on the south pole, a central vortex is surrounded by a pentagon of other vortices, and on the north pole, a central vortex is surrounded by an octagon of other vortices. By recreating the environment in a rotating shallow water model simulation, the properties of these vortices could be examined. In this simulation, 4 main variables were changed: vortex radius, outer vortex latitude, vortex strength, and gravity wave speed. In general, the vortices will drift to the pole until they touch, at which point they begin to merge into one large central vortex. Results showed that while the radius and latitude variables determined the length of time required to start touching, the vortex strength and gravity
wave speed variables determined how quick the merging process was; smaller strength and speed variables were associated with slower merging. Because a configuration in which the vortices never merged was never found, we can deduce that the simulation needs to account for more factors, such as jet streams, if it will ever recreate the observed phenomena.

Creating Mock Images for the JWST
Ben Calvin
Mentor: Philip Hopkins

We were tasked with creating an image processor for the James Webb Space Telescope. The telescope does not have an image processing algorithm because there is no sample data to use to test their routines. We used existing realistic simulation snapshots to create the data in bands that the James Webb will be operating in, and we were then able to create various viable representations. As one of the positive aspects of using infrared astronomy is its visibility through dust and gas, our visualizations tend to emphasize the dust hidden to visible observations. We also created a temperature mapping, as infrared is also traditionally used to detect temperature. The visualization methods and routines created will help translate data from countless infrared exposures, as well as simulations, into meaningful results and images.

Pyridinium Additives for Carbon Dioxide Reduction
Gabriella Chan
Mentor: Theodor Agapie

Renewable energy can be stored in hydrocarbon fuels via electrochemical carbon dioxide reduction. Currently, this method of hydrocarbon production competes with the hydrogen evolution reaction (HER), has high overpotentials, and experiences difficulty in selectively producing the desired hydrocarbons. To address these challenges, we developed pyridinium co-catalysts to be used with a copper electrode. The prevalence of hydrocarbon production from carbon dioxide reduction on copper electrodes was, for a significant period of time, believed to be a property unique to copper and remains as one of the highest product yield electrodes studied in carbon dioxide reduction research. Previously, pyridine increased methanol production when added to an electrolyte because aromatic N-heterocycles (ANH) lower the energy of the lowest unoccupied energy orbital (LUMO) making multi-electron/multi-proton transfer processes, such as carbon dioxide reduction, more energy efficient. To further investigate this phenomenon, we synthesized myriad pyridinium molecules as organic co-catalysts for carbon dioxide reduction. We expect these pyridinium compounds to increase carbon dioxide reduction's Faraday efficiency and methanol production while decreasing its hydrogen gas and methane production.

Characterization and Dispersion Compensation of Femtosecond Pulses With Prism Pairs
Jingjing Chen
Mentors: David Hsieh and Junyi Shan

It’s known that when a pulse passes through a dispersive media, the temporal profile of the pulse will change. A prism pair is a set of optical components used to compress the time duration of a positively chirped ultrashort laser pulse by giving different wavelength components different time delays, i.e., compensating the optical path difference generated by previous optical components. It typically consists of two prisms and a mirror. Frequency-resolved optical gating (FROG) is a method to measure the pulse width and the spectrum of an ultrafast laser pulse. We can use FROG to measure the pulse duration of the beam before and after the prism pair to assess the compression of the time duration. It is essential for ultrafast and nonlinear optical spectroscopy measurements since a shorter time duration of a pulse yields a better temporal resolution. What’s more, with the knowledge of the temporal profile of a pulse, one can carefully shape the pulse to pump an electronic system to some exotic states.

Simulating Observations on FIRE
Daniel Cushey
Mentor: Phillip Hopkins

Recent FIRE (Feedback In Realistic Environments) and Latte Project cosmological simulations explicitly treat stellar feedback at resolutions on the order of ~100pc, allowing constraints on fundamental \( \Lambda \)CDM parameters with unprecedented accuracy. However, analysis of simulation data must incorporate effects that are essential to the observation process before an accurate comparison against observational data can proceed. Here we implement the radiative transfer code SKIRT which simulates light propagation in the dusty interstellar medium of simulated galaxies and acts as a virtual observing instrument. We present simulated observations of selected objects generated using raw FIRE-2 data and justify observational parameters which were calibrated via comparison with a real dataset. Future observations may be used to verify parameters vital to cosmological simulations, visualize galaxy formation with high spatio-temporal resolution, and further constrain fundamental parameters of \( \Lambda \)CDM.
Characterizing CTCF Binding in X-Chromosome Inactivation
Ramya Deshpande
Mentors: Mitchell Guttman and Noah Ollikainen

CTCF is a zinc-finger transcriptional protein implicated in the formation of chromatin loops and involved in the regulation of X-chromosome inactivation. Elucidating the mechanism through which CTCF binding is reduced on the inactive chromosome is vital in understanding how topologically-associated domains (TADs) disappear and how three-dimensional genomic structure is altered during inactivation. ATAC-seq data in neuronal progenitor mouse cells for the active and inactive chromosome was overlapped with CTCF ChIP-seq data for mouse whole brain cells to analyze the impact of DNA accessibility upon CTCF binding; although the general trend pointed to lowered accessibility from the active (Xa) to inactive (Xi) chromosome where CTCF binding changed, with 75% of regions with a change in CTCF binding showing reduced ATAC-seq signal in the Xi, there were still a surprising number of regions which displayed little change in accessibility, although CTCF binding had changed. Subsequent motif analysis showed no significant enrichment in the set of regions with unchanged ATAC-seq signal in X. Further analysis was conducted to determine the contribution of a characteristic upstream and downstream flanking motif upon CTCF binding strength. Unravelling the mechanics of CTCF binding will ultimately reveal insight into how genomic structure is determined.

Simulation of Nanostructured Metal Surfaces for Intraocular Pressure Sensor Development
Nicole Feng
Mentors: Hyuck Choo and Haeri Park

The Choo lab has been developing an implantable intraocular pressure (IOP) sensor that relies on mechanical deformation to produce a detectable shift in reflectance when light is shined on the sensor. However, the mechanism is dependent on the light's angle of incidence, hindering convenient use by glaucoma patients. As proof-of-concept of an alternative, angle-independent mechanism, simulations of nanopores on an underwater metal surface were implemented in COMSOL Multiphysics and Surface Evolver software. The investigation focuses on the movement and stability of the air-water interface within the pores in response to pressure. Simulations of cylindrical, spherical, and other curved-wall pores ranging from 45 – 300 nm in radius and up to 900 nm deep were implemented. Pore dimensions and hydrophobicity were also varied to achieve pressure sensitivity within human IOP range. Evolver simulations were developed in tandem with those in COMSOL to further understand the wetting mechanism through energy analysis. The simulations provide insight into developing a practical pore-based IOP-sensing mechanism.

Determining the Wrong-Sign Component of a NOvA Beam in Anti-Neutrino Mode
Monika Getsova
Mentors: Ryan Patterson and Kirk Bays

In order for the NOvA experiment to be able to accurately study and compare neutrino and anti-neutrino oscillations, the wrong-sign component of a beam must be able to be determined with great accuracy. However, there is currently no way to directly measure the wrong-sign of an anti-neutrino beam. Using ROOT, I tested several proposed handles for determining the wrong-sign of the anti-neutrino beam using a Monte Carlo simulated data set as well as real detector data and statistical methods such as chi-squared analysis to determine each handle's efficacy. If, through further research, a method is developed that can measure the wrong-sign component of an anti-neutrino beam, then exciting new information can be gained about the neutrino mass hierarchy as well as CP violation in neutrinos.

Modeling the Role of Thermally-Activated Viscous Flow in Subduction Zone Slow-Slip Events
Arjun Goswami
Mentors: Sylvain Barbot and Jean-Philippe Avouac

Slow-slip events (SSEs) are earthquake-like events characterized by low slip rates. While peak coseismic velocities can reach tens of meters per second, SSEs can be as slow as on the order of $10^{-7}$ m/s, with slip lasting for days or weeks. Under the widely-used rate-and-state model of fault friction, only a narrow range of frictional parameters can produce SSEs. However, SSEs are common in subduction zones worldwide, which presents a conundrum. It is unlikely that subduction zones across a wide range of international sites embody the same narrow range of parameters. The ubiquitous phenomenon of SSEs on subduction zones can alternatively be explained by thermal effects. Shear heating and high temperatures at depth induce melting and thermally-activated viscous flow. This velocity-strengthening mechanism inhibits fast ruptures. To investigate, a dynamic, semi-brittle model of a fault is implemented, which incorporates both friction and flow as constitutive properties. Exploration of the parameter space, and observation of the thermal behaviors accompanying slip events, can lend insight into the fundamental nature of subduction zone SSEs.
Encapsulation Methods for Thermosensitive Pectin Films
Richard T. Hamel
Mentor: Chiara Daraio

As autonomous robotic systems grow more advanced, the need for more sophisticated sensors grows more apparent. One of the more difficult sensory devices needed is a robotic skin since such a sensor must be flexible to function. Dried pectin treated with calcium ions forms a flexible film whose conductivity is highly dependent on its temperature, making it an excellent thermosensitive skin for applications where it must conform to mobile architectures like robotic arms and joints. While these skins are quite sensitive to temperature, they are also hygroscopic, making them very sensitive to humidity as well, diminishing its usefulness for accurately sensing temperature. This study examines several encapsulation methods to protect thermosensitive pectin films from humidity changes and make them viable as useful thermosensitive devices.

Understanding the Propagation Mechanisms of Vocal Fold Vibrations in the Human Head for Implantable Vibration-Driven Energy Harvesters
Yeokyoung Kil
Mentors: Hyuck Choo and Hyunjun Cho

Advances in medical engineering have led to a trend of surgically implanted medical devices. Despite their many advantages, these medical implants pose major risks because they need their batteries surgically changed periodically. The Choo Lab has designed an implantable piezoelectric energy harvester that uses vocal fold vibrations to power these medical implants. This project seeks to find the optimal site for implanting the energy harvester. In order to do so, a finite-element model of the head was created with the 3D image processing software ScanIP, using publicly available CT scans. Simulations on vibration propagation were run on this model using the acoustic-structure interface of COMSOL Multiphysics®. An anatomical model of the human head was also used to map the vibration measurements on the human head. Combining these results will hopefully help determine the optimal implant location of the energy harvester.

Data Analysis of Laminar Flame Speeds
Minjae Kim
Mentor: Guillaume Blanquart

This research seeks to unify our current model for laminar flame speeds of carbon based fuels by analyzing pre-existing data with a more holistic approach. Most of the data currently attempts to compare the laminar flame speeds of only one type of fuel in various experiments. There is a distinct lack of data in this method. However, there is an abundance of data if the various types of carbon-hydrogen based fuels are compared together in one plot within the same system. Through these comparisons, we will try to verify that our fuels exhibit identical SL variations between the experimental model and simulated model at various φ, T, and P. In order to do this we are optimizing the various analytical functions that result from graphing all the flame-speed data of the different fuels together and comparing them to that of simulation data to find an overarching algebraic model. We seek to quantify the fit of our experimental data with an all encompassing function.

Path Planning and Navigation on the Cassie Biped
Filippos Lymperopoulos-Bountalis
Mentors: Aaron Ames, Jake Reher, and Wenlong Ma

Bipedal robots are especially useful for navigating semi-unstructured environments as well as interacting with humans. One of the primary challenges to navigation on bipedal robots is planning feasible walking paths for which the robot can select stable footstep locations. The main goal of this work is to facilitate the implementation of path planning algorithms which can generate efficient walking routes for the bipedal robot Cassie around the Caltech campus. After creating a Digital Elevation Model to locate walkway grades for reference in navigation and an occupancy grid to mark allowable walkways, the remaining goal of this project is to create the necessary software for Cassie to walk on this simulated uneven terrain using the Robot Operating System (ROS).

Alaska: A Framework for Automated, Complete RNA-Seq Analysis
Kyung Hoi (Joseph) Min
Mentors: Paul W. Sternberg and David Angeles-Albores

A typical RNA-sequencing (RNA-seq) workflow consists of generating libraries to obtain reads, aligning them, and identifying the genes that are differentially expressed in response to a perturbation. At the end of the workflow, the reads are submitted to the Gene Expression Omnibus (GEO). Although the molecular biology behind RNA-seq is well understood, the computational analysis remains challenging because researchers must learn how to operate complex software correctly. Moreover, GEO metadata do not use controlled ontology—this decreases the reusability of the dataset and prevents its incorporation into databases such as WormBase, decreasing its impact. These difficulties prevent labs without dedicated experts from incorporating RNA-seq into their day-to-day workflow. We introduce a fully automated RNA-seq framework, which we call Alaska. Alaska automatically infers the correct way
to analyze an experiment from user input and performs all downstream analyses. The data are automatically submitted to GEO along with the appropriate metadata, which is written using a controlled ontological language. This allows databases to automatically perform powerful meta-analyses, and enhances indexing and searching of experiments, maximizing the impact of each dataset on the scientific community. The entire process from input to output is performed in minutes and requires no technical expertise.

**Mean Field Analysis of Recurrent Neural Networks**
Sarang Mittal
*Mentors: Maria Spiropulu, Stephan Zheng, and Jean-Roch Vlimant*

We analyze the dynamics of recurrent neural networks whose initial weights and biases are randomly distributed. Utilizing mean field theory and making some mean field approximations, we develop a theoretical basis for length scales which limit the depth of signal propagation in a one layer recurrent network with long input or prediction sequences. For specific hyperparameter choices, these length scales diverge. Building on the conclusions of Schoenholz et. al. (1), we argue that random recurrent networks can only be trained if the input signal can propagate through them. This suggests that recurrent networks can be trained with arbitrarily long sequences provided they are initialized sufficiently close to criticality. We begin searching for empirical evidence in support of our conclusions, and provide some preliminary results.

**Automated System for Electrochemical Activation of Neural Probe Microelectrodes Used for Recording and Stimulating Brain Activity**
Antonio Monreal
*Mentors: Thanos Siapas and Gustavo Rios*

The underlying neural mechanisms governing brain functions such as perception, emotion, learning, and memory currently remain poorly understood. What is known is that these functions emerge from the coordinated interactions of billions of neurons distributed throughout the brain. These interactions are in the form of electrical pulses which can be monitored using microelectrodes. Until recently, neural probes were limited to have about 100 recording microelectrodes and, thus, can sample neuronal activity only very sparsely. The Siapas Lab has developed nanofabricated neural probe arrays that drastically increase the number of recording microelectrodes into the thousands. While these microelectrode arrays are an improvement over previous electrophysiological systems, the tissue-electrode interface requires further modification to maximize their performance. Electrodeposition of conductive polymers has been shown to drastically reduce the electrical impedance of microelectrodes, thus, reducing noise, and even allow for safe electrical brain stimulations. Implementing this across thousands of microelectrodes is a challenge since the depositions are hard to replicate and time-consuming. To systematically apply this technique, we developed a fully automated, microfluidic-based system that allows for sequential electrodeposition of conductive polymers onto hundreds of microelectrodes along with electrochemical characterization of their electrode-electrolyte interface.

**An Elementary Proof of the Landsberg-Schaar Relation and its Generalization**
Christopher Moon
*Mentor: Zavosh Amir-Khosravi*

The Landsberg-Schaar Relation is a relation that only involves finite sums, yet the only known proof relies on limits of infinite sums. This project was to show an "elementary" proof to the relation that did not rely on complex analysis as well as for its generalization, the generalized quadratic reciprocity law for Gauss sums. We have successfully demonstrated a proof that relies solely on finite methods using a direct application of a discrete analog of the Poisson summation formula. The same method can be used to prove its generalization. Furthermore, by translating our method, we hope to generalize proofs of the relation even further to say finite abelian groups.

**Utilizing Sentinel-1 Radar Amplitude Data to Model Larsen C Rift Propagation**
Kayla Owens
*Mentors: Mark Simons and James Dickson*

The Larsen C ice shelf in Antarctica has been rifting since 2010, and the rift propagation began significantly accelerating in 2016. The Sentinel-1 satellites use interferometric synthetic aperture radar (InSAR) to image the rift, returning both amplitude and phase data. The amplitude data from these satellites was processed and filtered in order to track rift propagation. The data sets were georeferenced using Sentinel-1 orbit data and projected in order to visualize the relative rift movement. After the data showed a few weeks of very little rift development in June, we observed the ice shelf calve between July 6th and 12th. Radar data at the rift tip was processed back to late 2015 with the intention of creating a time series of the propagation. Subsequent work would begin by creating this time series, then more accurately coregistering the images into a stack and using phase data to observe the mechanics behind the rifting.
A Functional Screen of Pre-Committed T Cell Genes Using CRISPR-Cas9
Nikhita Poole
Mentors: Ellen Rothenberg and Xun Wang

T cells are a critical component of the human body's adaptive immune system, which is designed to recognize and target specific pathogens. The presence of T cells is necessary in order to mount a full immune response, so any problems with them, such as T cell leukemias, are extremely damaging. Thus, understanding the mechanisms of T cell development from hematopoietic stem cell precursors is crucial because it offers insight into both the process of stem cell differentiation and the origins of T cell leukemias. Several genes have been found to be heavily influential in the early stages of T cell development, particularly one known as PU.1. PU.1 is a regulator of a number of other genes, but the functions of these targets are currently unclear. To elucidate their roles, we will use the CRISPR-Cas9 system to disrupt these target genes in cells prior to T cell commitment, and examine the resulting effects on the cells' developmental progression. This initial screen will allow us to identify particularly significant genes that merit deeper exploration, and thus may pave the way for further studies that will provide new insight into the control of progression through T cell development.

Rapid, Isothermal Nucleic Acid Amplification for Detection of Antimicrobial Resistance
Amrita E. Rhoads
Mentor: Rustem F. Ismagilov

Antimicrobial resistance (AMR) has become a growing threat in the past decades, due in part to overprescription of antibiotics to treat minor infections, failure of patients to take an entire course of antibiotics, and development and transmission of colonies of resistant infections in hospitals. Under current models of prediction, antibiotic resistant diseases will be poised to kill 10 million people a year by 2050, far exceeding the current death toll of cancer (O'Neill 2016). Ongoing work focuses on rapid and isothermal phenotypic tests for antibiotic susceptibility, in a way such that these tests may be carried out in point-of-care settings and do not depend on the presence of specific resistance genes. Currently, nucleic acid amplification remains a promising avenue of research -- by quantifying DNA content in samples in the presence and absence of antibiotic treatment, one could determine whether antibiotic presence inhibited bacterial growth (Schoepf et al. 2016). LAMP, or loop-mediated isothermal amplification, functions as a single-step method of amplification with highly specific results. A variety of other methods for rapid and/or isothermal amplification, such as RCA, SDA, or HDA present themselves as viable alternative methods of amplification as well. This project examined the viability of these methods in comparison to LAMP in terms of primer design, robustness, and speed, first by designing protocols for low-volume DNA amplification with real-time measurement and then by optimizing conditions for rapid nucleic acid detection.

Effects of Supernovae Explosions on Ultra-Faint Galaxies
Milan S. Roberson
Mentors: Andrew J. Benson and Shrinivas R. Kulkarni

Semi-analytic models of galactic evolution treat supernovae (SNe) as continuous sources of energy that provide a negative feedback on star formation. While this continuum approximation is valid for large galaxies, SNe are in fact discrete events; the energy output from just one can completely disrupt the star forming regions of the smallest galaxies. We present modifications to GALACTICUS, a semi-analytic model of galaxy formation, that implement discrete SNe in low mass regimes where the continuum approximation breaks down. To ensure convergence between the discrete and continuous approaches, the mass of gas ejected by SNe is determined by the continuous approximation's rate of mass outflow. We find that the discrete SN approach agrees more closely with the mean star formation history of a sample of dwarf galaxies in the Local Group at mass cuts of log M/M☉ ≤ 6 and log M/M☉ ≤ 7.

Investigating the Relationship Between Leader and Follower Cells During Collective Cell Migration Through the Use of Zebrafish Trunk Neural Crest Cells
Max Shen Molesky
Mentors: Marianne Bronner and Ezgi Kunttas-Tatli

The neural crest (NC) is a multipotent embryonic cell population present in vertebrates that migrate collectively throughout the body during embryonic development and differentiate into several cell types including bone and cartilage of the face, neurons and glia in the peripheral nervous system. Improper development of the NC is the cause of one third of all congenital birth defects and cancers such as neuroblastoma and melanoma; thus, the study of these unique cells is pertinent to medical research. In this study, we used advanced imaging technology combined with genetic tags in zebrafish embryos to better understand the collective migration behavior of trunk NC cells. First, we used a Sox10Gal4-UASlifeactGFP line to label the actin cytoskeleton in migrating NC cells and analyzed the cellular behavior between leader cells and the follower cells. We then used a Ct122a-Sox10mRFP line to label the environment that NC migrate through and analyzed the relationship between NC cells and surrounding cells as well as the speed and directionality of multiple streams during migration. In the future, we will also label the nuclei of these cells to be able to track each cell to further analyze the relationship between cells during collective migration.
Various Filters of the Guided Entry of Tailed-Anchored Proteins Pathway Reject the Translocation of Signal Recognition Particle-Independent Pathway Substrates
Woo Jun Shim
Mentors: Shu-ou Shan and Hyunju Cho

As one-third of proteins is translocated into the endoplasmic reticulum (ER), an efficient mechanism to translocate nascent protein to the ER is essential for a properly-maintained homeostasis in *Saccharomyces cerevisiae* yeast cells. A major group of protein translocated to the ER called tailed-anchored proteins (TAs) has their transmembrane domain (TMD) in the C-terminus. It is known that TAs follow post-translational targeting of the guided-entry of TAs (GET) pathway to the ER; however, the filters with which and the mechanism by which the GET pathway rejects non-GET pathway substrates is poorly described. We use glucose-signaling factor 2 (GSF2) that contains a central TMD as the model substrate of the signal recognition particle-independent (SND) pathway to delineate such selection filters of the GET pathway. By measuring the translocation efficiency of GSF2 in various SND mutants through immunoblotting, we will confirm that GSF2 is indeed a substrate of the SND pathway. Subsequently, turbidity assay *in vitro* and pulse-chase experiments *in vivo* will determine the binding of GSF2 to Hsp70 (Ssa1), a promiscuous hub in the upstream of the GET pathway. Pulldown assay and fluorescence resonance energy transfer (FRET) assay will show that Sgt2 (adjacent GET pathway downstream of Ssa1) rejects the transfer of GSF2 from Ssa1.

Optimization of Methods to Find Extreme Galaxies in the CLU 3σ Galaxy Survey
Bethany Suter
Mentors: Mansi Kasliwal and David Cook

In the past decade, galaxies with extreme properties called green peas and blueberries have been found at low redshift which are likely analogs for galaxies that formed shortly after the Big Bang. Originally found through visual inspection, the number of blueberries and green peas grew slowly. To automate the selection process, we use colors from multiple imaging surveys (i.e. SDSS, WISE, and GALEX) that span a broad range of wavelengths to more cleanly separate these galaxies from a random sample of galaxies and QSOs. Our color cuts found 92% of the targeted extreme galaxies, while previous studies using optical-only color cuts found 30%. Furthermore, our method is missing about 9% of the extreme galaxies and has a contamination percentage of 3-4%. We applied these color cuts to an area of the sky that overlaps with the CLU (Census of the Local Universe) survey which can provide confirmation of their extreme properties by measuring the star formation rate via imaging. We found about 17,000 blueberries and green pea candidates. We present the physical properties (star formation rate, metallicity, and stellar mass) of a subset which have been spectroscopically confirmed and investigate whether these extreme galaxies follow the trends of regular galaxies.

Analysis of Parameterization of Boundary Layer Turbulence and Clouds for Climate Modeling
Nicholas Trank
Mentors: Tapio Schneider and Colleen Kaul

For reasons of computational cost, global climate models use spatial resolutions that are too coarse to directly represent turbulent mixing and clouds. Approximate relationships, called parameterizations, are used to represent the effects of these unresolved processes on large-scale atmospheric flow. One such parameterization is called the Eddy-Diffusivity/Mass-Flux approach, which assumes that all air movement can be either categorized as a turbulent environment that has an eddy diffusivity behavior, or as coherent updrafts that satisfy mass-flux equations. To inform parameterization development, limited-area models called large-eddy simulations (LES) are used. In this work, we investigate a novel approach to EDMF parameterizations that includes updraft "memory" terms and a systematic derivation of the budget of turbulent kinetic energy. Simulations of shallow cumulus convection were run to determine whether some of the assumptions made in the current model are supported by LES data. Important variables, such as the entrainment and detrainment rates of the updrafts, were also investigated to attempt to identify useful parameterizations. We found that even though the parameterization is able to capture many features of shallow cumulus convection, there are some assumptions that are not supported by LES data, suggesting areas in which the parameterization could be improved.

Establishing a Specific and Efficient T-cell Activation Reporting System for Identifying Antigen and T-Cell Receptor Interaction
Jessica Wang
Mentors: David Baltimore and Guideng Li

T-cell receptors (TCRs) are cell surface receptors that help T-cells recognize invading microbes and infected or cancerous cells in the body. TCRs bind specifically to antigens expressed on diseased cells and activate gene transcription in the T-cell in order to initiate an immune response. Since TCR specificity and response depend on TCR-antigen pairing, a method called T-cell receptor gene therapy has been used to enhance the immune system's response to cancer cells. In this method, T-cells from a patient are genetically altered to express TCRs targeting antigens specific to, or associated with, the patient's tumor cells. Thus, identifying the TCR that can recognize a specific antigen and identifying the antigen that can be recognized by a specific TCR are both very important for
TCR-based gene therapy. We have established two reporting systems for verifying antigen-TCR pairs. The first reporting system is a TCR reporting system that uses NFAT-controlled expression of ZsGreen. The second reporting system is a synthetic Notch (synNotch) receptor reporting system using Gal4-VP64-controlled expression of ZsGreen. Response and specificity of these systems will be compared to determine which method is more efficient. In the future, this reporting system can be used as a tool for TCR-based gene therapy.

**Implementation of Multi-Agent Controlling Architecture for Micro-Quadrotors**

Qifan Wang  
*Mentors: Soon-Jo Chung and Kyunam Kim*

With the introduction of commercially available micro-quadrotors, efficient algorithm for controlling and guiding swarms of such quadrotors have become a major area of interest. An architecture of control system, with a powerful controlling algorithm, has been developed as a legacy of previous researchers, but its implementation lack robustness and versatility. A new way of implementing such architecture is proposed by using the Robotic Operating System (ROS), which allows easy development and experimentation of controlling algorism, while preserving the virtue of the existing architecture. It is hoped that such system will efficiently and accurately control a mass swarm of micro-quadrotors with complex trajectories.

**Intraocular Pressure (IOP) Sensor Testing Chamber Design**

Asta Wu  
*Mentors: Hyuck Choo and Haeri Park*

Elevated intraocular pressure (IOP) has been linked to the development of glaucoma. A method of measuring IOP utilizes the IOP sensor, and part of the testing process of the IOP sensor involves placing the sensor into a testing chamber. Light is shown into the chamber and the reflected beam is analyzed with a spectrometer. The current testing chamber restricts freedoms in measurements performed on the IOP sensor. The setup only allows for measurements to be performed directly above the chamber, and the chamber lid is too thick, limiting the angles of light projection into the chamber. Our goal is to redesign the testing chamber and testing setup. The resulting chamber will be able to stand upright such that light can be shone horizontally into the chamber, and the lid thickness will allow for greater degrees of freedom in light projection. Furthermore, the testing system – a pressure gauge and pressure regulator – attached to the chamber will be compatible with the new chamber. The testing system will function under hydraulic conditions and allow for precise measurements between 0 and 350 mmHg. This device will be put into practical testing in the future.