BARNARD

Summer Research Institute

Poster Session
July 28th, 2017
10:30am-12:30pm
The Event Oval

Photo by Brian Mailloux

2017 SRI Poster Session: Schedule of Events

10:30	**Welcome: Professors John Glendinning and Christian Rojas, Principal Investigators**
10:30-11:30	**Students with even-numbered posters present**
11:30-12:30	**Students with odd-numbered posters present**
12:15	**Remarks: Provost Linda A. Bell**

Refreshments will be available

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Amgen Foundation
Anne Davidson Fellowship
Arnold and Mabel Beckman Foundation
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The Class of '59 Science Internship Fund
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Within the Barnard Community, the following deserve recognition for their important contributions to the Summer Research Institute:

The Empirical Reasoning Lab
The Office of the Dean of the College
The Office of the Dean of Studies
The Office of Development
The Office of the Provost

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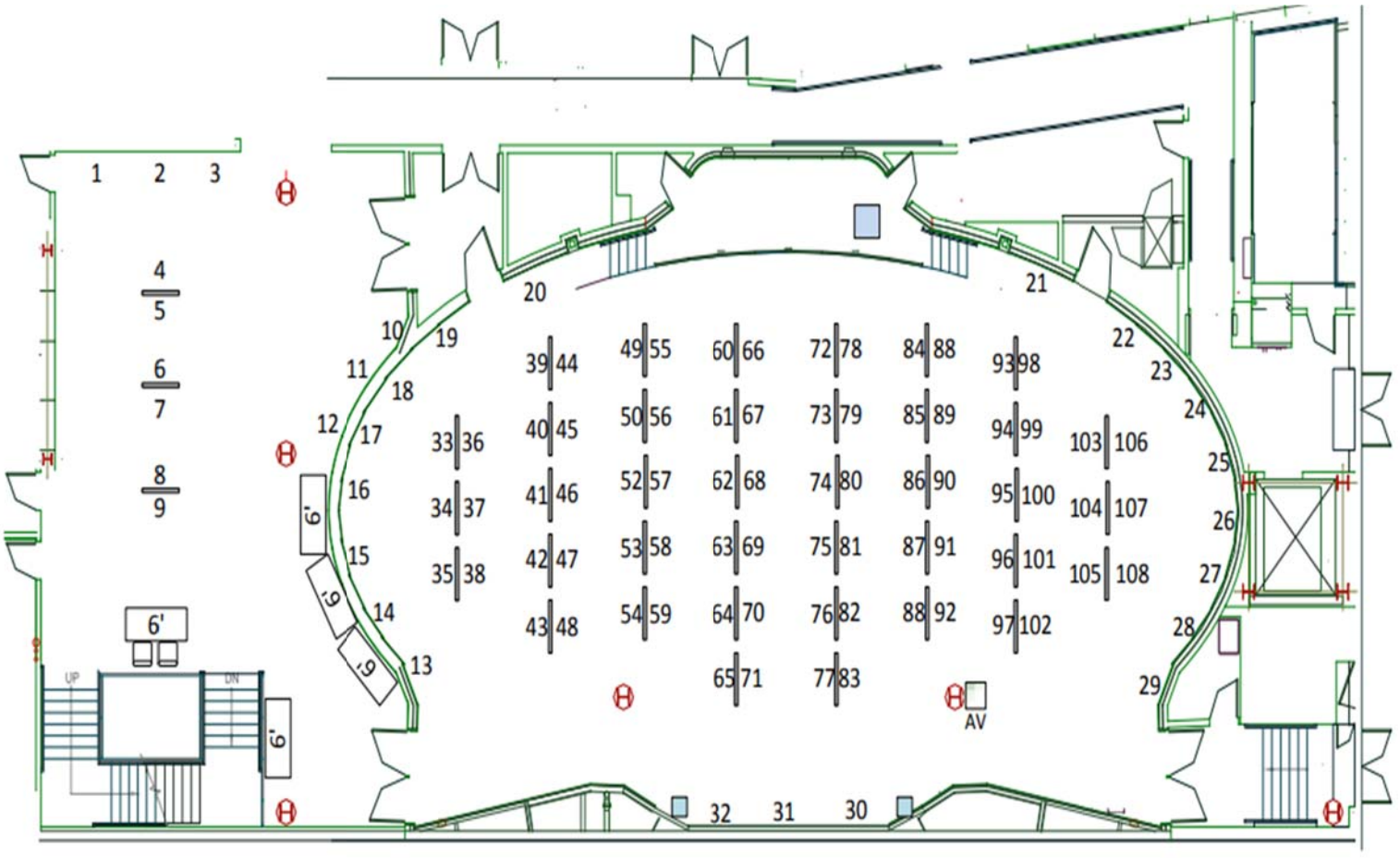
SRI Poster Session 2017

Friday, July 28th

The Diana Event Oval

10:30am-12:30pm



BIOLOGY

1. Characterization of the Oxidative and Heat Shock Response in Apis mellifera

Dunay Bach and Samantha Shih
Mentor: Jonathan W. Snow,
Department of Biology, Barnard College

The Western Honey Bee, *Apis mellifera*, is a critical pollinator in both agricultural and ecological settings. These insects pollinators provide a global service worth $215 billion to food production (Goulson, 2015). In fact, 75% of crop species benefit from insect pollinators (Goulson, 2015). Unfortunately, honey bees are subject to a variety of pressures in the modern world including habitat loss, parasites and infectious disease, pesticides, competition, climate change, as well as interactions between these stressors (Goulson, 2015). In order to maintain general homeostasis, honey bees undergo cellular stress responses to buffer certain external factors (e.g. stressors above) that perturb internal balance. The Snow lab is interested in the cellular stress responses of honey bees and how they contribute to honey bee health individually and in combination. Our particular project worked to characterize the heat shock response (HSR) and oxidative stress response (OxSR) in honey bees. In particular, unfavorable changes in temperature and oxidative stress could interact synergistically on honey bees. Possible explanations are that there is not enough metabolic capacity to simultaneously respond to both stressors, or maybe that heat affects the chemistry or bioavailability of oxidants (Julian, 2016). By inducing the HSR and OxSR we were able to analyze which genes were expressed at higher rates in each organism. Further research in this lab is aimed to understand how these two cellular stress responses interact with one another, and whether or not there is a synergistic effect on honey bee health.

2. In Vivo Bone Adaptation Under OPG and Mechanical Loading

Ana Lam
Mentor: Samuel Robinson
Department of Biomedical Engineering, Columbia University

Mechanical loading is integral to bone's ability to structurally adapt and maintain homeostasis as demonstrated by Wolff's Law. However, the underlying mechanisms that accompany this adaptation remains unclear. Osteoblasts and osteoclasts are bone forming and bone resorbing cells which work in a coupled behavior to remodel bones. When this behavior is uncoupled, bone is modelled in a unique way often due to loading or unloading. Osteoclasts are multinucleated bone cells involved in bone resorption activity. Their differentiation through factor RANKL is key in mediating the response to mechanical load. OPG, the decoy receptor to RANKL, inhibits osteoclast differentiation. We hypothesized that with a OPG treatment and mechanical loading, mouse models would exhibit less osteoclast activity and have a thicker bone composition with greater bone density. To examine the effects of OPG on osteoclast activity, mouse models were injected with OPG or a vehicle for 7 weeks. Mechanical loading was performed for 5 weeks to observe the effects of loading coupled with OPG treatment. Bone marrow was collected to be analyzed via flow cytometry and scanned tibia using micro-computed tomography was used to observe changes in the physical components of the tibia. Histochemical analysis through a TRAP stains was performed on the sagittal sections of dissected mice tibia. Osteoclasts express TRAP, a lysosomal enzyme. We are expecting to see a decreased number of osteoclasts and thicker bone with OPG. OPG is projected to have an inhibiting effect on bone resorption making it a possible treatment for diseases such as osteoporosis.

3. Role for the FGFR Pathway in Cutaneous Merkel Cell Carcinoma

Amelia Baier
Mentor: David Owens
Department of Dermatology, Columbia University Medical Center

Merkel Cell Carcinoma (MCC) is a rare but aggressive form of skin cancer with unknown etiology. MCC incidence has tripled over the last decade and this lesion is largely resistant to adjuvant chemo- and radiation therapy. While UV radiation and MCPyV-encoding T oncoproteins are reported to play a casual role in MCC, resulting therapeutic targets are yet to emerge. As such, there is a major unmet medical need for novel therapeutic approaches for this potentially lethal form of skin cancer. Previous studies in our laboratory identified the FGF pathway as a putative regulator of Merkel cell homeostasis in normal skin. Therefore, we investigated whether FGF signaling may also play a role in MCC pathogenesis. We detected high mRNA expression for FGFRs 1-3, but not FGFR4, in 5 primary human MCC specimens and MCC26 (MCPyV-negative) and MS-1 (MCPyV-positive) cell lines through RT-PCR analysis. In addition, we immunolocalized FGFR2 protein expression to Krt8+ Merkel cells in human MCC tissue. Collectively, our findings show that overexpression of FGFRs is a common feature of human MCC tissue and derived cell lines. To investigate a functional role for FGFRs 1-2 in MCC, siRNA-mediated knockdown of FGFR mRNA was performed on human MCC cell lines and we assessed its impact on MCC cell growth. Our results indicated efficient knockdown of FGFRs 1-2 in the siRNA treated cells compared to cells transfected with non-silencing control siRNAs. We will continue by conducting cell growth assays to test our hypothesis that FGFRs contribute to MCC proliferative cell growth.

4. Hepatic FoxOs Regulate HDL-Mediated Reverse Cholesterol Transport

Gabriella A. Belnavis
Mentor: Rebecca Haeusler
Department of Pathology, Columbia University Medical Center

Patients with insulin resistance and type II diabetes (T2D) have a two-to-four-fold increase risk for cardiovascular disease (CVD), but the mechanism behind this correlation is not completely known. Reverse cholesterol transport (RCT) provides a possible connection between insulin resistance and cardiovascular disease. RCT is a cardio-protective pathway that removes excess cholesterol from tissues throughout the body to the liver via high density lipoprotein (HDL) particles, to be either catabolized to bile acids or excreted in the feces. RCT utilizes the proteins such as apolipoprotein A1 (APOA1), ABCA1, scavenger receptor class B member 1 (SR-BI), and hepatic lipase (HL). Hepatic forkhead transcription factors of the FoxO sub-family, FoxO1, FoxO3, and FoxO4 (FoxOs), mediate insulin's effects on both glucose and lipid production in the liver. During fasting periods, FoxOs are activated and stimulate genes involved in hepatic glucose production (HGP) and bile acid synthesis. Here, we investigated the effects of liver-specific FoxO1, FoxO3, FoxO4 knockout on HDL-cholesterol metabolism using polymerase chain reaction (PCR), quantitative PCR (qPCR) western blots and fast protein liquid chromatography (FPLC). Our data suggests that hepatic FoxOs are required for normal expression of HL and SR-BI, two major proteins that are required for HDL-mediated RCT, a key mechanism of lipid homeostasis *in vivo.*

5. Modeling Bile Acid Signaling in Primary Gut Organoids

Nushrat Chowdhury
Mentor: Rebecca Haeusler
Department of Pathology, Columbia University Medical Center

Bile acids are the products of cholesterol metabolism and the major route for cholesterol excretion from the body. They also function as signaling molecules acting as endogenous ligands of the farnesoid X receptor (FXR). FXR is a nuclear receptor that regulates transcription of genes involved in metabolism of lipids, bile acids (e.g. *Cyp7a1*, *Fgf15*), and glucose (e.g. *Gcg*). Interestingly, bile acids have been shown to differentially affect FXR activation and, consequently, FXR-dependent transcription. Here, we investigated how ursodeoxycholic acid (UDCA) and muricholic acid (MCA) affected FXR activity in a model of the small intestine. UDCA and MCA have previously been reported as antagonists of FXR. Previous studies also suggest intestine-specific inhibition of FXR improves insulin resistance and obesity. We used primary gut organoids derived from mouse ileum for our studies because (i) it is where most bile acids are reabsorbed and (ii) ileal enterocytes highly express FXR. We treated these organoids with bile acid mixtures of varying compositions for 20 hours. We then measured expression of FXR and FXR-mediated genes with qPCR. Analyzing gene expression in these organoids may be useful in better understanding how different FXR antagonists affect metabolic regulation. Such findings may contribute to the development of treatments for metabolic diseases in which FXR is treated as a drug target.

6. Using Datavyu to Analyze the Fidelity of a Dance Intervention for People with Parkinson's Disease

Elizabeth McAneny
Mentor: Lori Quinn
Department of Biobehavioral Sciences , Teachers College

Recently there has been an increasing amount of research on dance and Parkinson's disease (PD). These studies are difficult to reproduce because of the overall complexity of dance interventions. In order to more precisely study the effects of dance interventions on patients with PD, a more reproducible method of analyzing dance and quantifying movement patterns had to be created. The aims of this study were to test the feasibility of using Datavyu (an open sourced video analysis software) to analyze the fidelity of dance interventions for people with PD and to develop a reproducible method for analyzing these dances. Using videos of dances choreographed for a PD dance intervention, we developed a code based on body segments and anatomical planes of motion in order to provide a comprehensive description of movement in the dance. After coding the entire video in Datavyu, Datavyu produced quantitative data about time performing each type of movement. Overall, Datavyu is an effective tool for quantifying movement patterns in dances because it's simple, it's time efficient, and it allows users to create their own codebook and export data about time. This method can promote reproducibility among studies evaluating the efficacy of dance interventions for patients with PD because it allows dances of different styles to be compared. It can also help identify the key elements of dances that enhance patient outcomes. This method of analysis will be used in a pilot study that will evaluate the effects of dance on gait bradykinesia in patients with PD.

7. A role for HOF1, DBF2, and MOB1 in the contractile ring closure of budding yeast with severe mitochondrial inheritance defects

Hana Koob
Mentor: Liza Pon
Department of Pathology & Cell Biology, Columbia University

Recent studies provide evidence of a cell cycle checkpoint that blocks cytokinesis in *Saccharomyces cerevisiae* with defects in mitochondrial inheritance. In particular, research has focused on the Mitotic Exit Network (MEN), a signaling pathway that regulates the mitochondrial inheritance checkpoint, and contractile ring closure in yeast with mitochondrial inheritance defects.[1] This study characterized the protein Hof1, which is involved in contractile ring closure, as well as the MEN proteins Dbf2 and Mob1, which regulate the localization of Hof1p in yeast. These proteins were localized in yeast with and without mitochondrial inheritance defects and it was found that all three proteins were recruited to the mitochondria in cell strains with defects in mitochondrial inheritance.[2] *Mdm10*Δ mutants were employed in the study because the deletion of *MDM10*, a component of the mitochore, produces cells with defects in mitochondrial inheritance.[2, 3] The temperature sensitive *myo2-14* strain was also used in the study and was verified to have defects in mitochondrial inheritance at restrictive temperatures (36° C) but not at permissive temperatures (25°C). The study concluded that Dbf2p and Mob1p recruit Hof1p to the mitochondria in *mdm10*Δ mutants and temperature sensitive *myo2-14* mutants as part of a cell cycle checkpoint that inhibits contractile ring closure and blocks cytokinesis.[2] My project expanded on these studies to substantiate the finding that the absence of mitochondrial inheritance results in the blocking of cell cycle progression. Here, I used a different mutant strain *ypt11*Δ, *mmr1-5*, which also produces cells with defects in mitochondrial inheritance, and investigated whether these cells show an inhibition of contractile ring closure as well.

8. Role of STAT3 signaling in small cell lung cancer metastasis

Hanna Scholze
Mentor: Anup Biswas and Swarnali Acharyya
Institute for Cancer Genetics, Columbia University Medical Center

Small cell lung cancer (SCLC), which accounts for 15% of all lung cancers, has a survival rate of 5%. Loss of both tumor suppressors, TP53 and Rb, is a hallmark of SCLC. It is a highly metastatic, neuroendocrine tumor type. Most metastatic SCLC patients relapse within 1 year after initial drug response. However, little is known about what mediates metastasis in SCLC cells. Using an orthotopic mouse model, with cancer cells derived from *Rb/p53/p130* triple knockout mice, we are exploring mechanisms of SCLC metastasis. In this model, 100% of mice that have these cancer cells implanted in the lungs will develop metastases in the liver. Examination of cell growth and survival pathways by phospho-protein immunoblot analysis revealed that Signal transducer and activator of transcription 3 (STAT3) is activated in the liver metastases from the SCLC models. STAT3 is known to play an important role in the progression of many cancers, but its function in SCLC remains elusive. *In-vitro* treatment with STAT3 inhibitor, Stattic, sensitized SCLC cells to cell death, indicating that STAT3 mediated signaling could promote SCLC survival. We are exploring the mechanism of action of STAT3 in regulating SCLC growth and survival. To explore the function of STAT3 *in-vivo*, we are using the CRISPR/Cas9 genome editing technology to delete the STAT3 gene from SCLC cells. These STAT3 knockout cells will be used for *in-vivo* analysis of STAT3 function in SCLC metastasis. Thus, our study will elucidate the function of STAT3 in metastasis and survival of SCLC tumor cells.

9. ***Development and differentiation of the somatic progenitor cells in the Drosophila ovary***

Helen Kogan
Mentor: Daniel Kalderon and Amy Reilein
Department of Biological Sciences, Columbia University

Somatic Follicle Stem Cells (FSCs) in Drosophila ovaries provide a useful model system for analyzing the interactions between developing stem cells and their somatic cell microenvironment. The germarium, located in the anterior tip of each ovariole, contains two types of cells in the larval stage: germline cells and somatic progenitors. The somatic progenitors within the germarium differentiate into 14-16 FSCs in the adult germarium, and around 25 to 30 ECs. ECs are positioned anterior to FSCs in regions designated as 1 and 2a, while FSCs are positioned in the region known as 2b. This project is aimed at identifying how they are specified into those positions, as well as defining the time point at which mature non-dividing ECs have formed. By labeling dividing cells originating at different time points in the pupal ovary with EdU, a nucleoside analog, we are examining the location of EC division and differentiation patterns. We found that at 50 hours after pupation, ECs have largely stopped dividing in Region 1 of the germarium, but continue to divide in Region 2a. I will analyze the germarium in earlier stages of development to identify the specific time points at which ECs in Region 1 become specified as adults by determining when they stop dividing. I intend to utilize an antibody to Traffic jam in order to better visualize all somatic cells in the developing germarium. This study complements an ongoing study focused on lineage analysis of ECs.

10. Determining mechanisms of Hoxa5 function via tissue-specific deletion in lateral plate mesoderm

Jenna M. Bergmann
Mentor: Jennifer H. Mansfield
Department of Biology, Barnard College

Hoxa5 is one of 39 mammalian *Hox* genes, a family of transcription factors essential for the proper morphological development of tissues along the body axis, including the vertebral column. The *Hoxa5* loss of function phenotype is perinatal lethal and includes homeotic transformations, or transformations of one structure into another, in vertebrae around the cervical-thoracic transition. The mechanisms through which the Hoxa5 protein regulates these structures, such as its transcriptional targets and the embryonic tissues in which it functions, remain unknown. This project will test which tissue types require Hoxa5 for skeletal patterning. *Hoxa5* is expressed in both of the embryonic mesoderm populations that contribute to the musculoskeletal system: the somitic mesoderm and the lateral plate mesoderm (LPM). In order to determine the contribution of *Hoxa5* expression in the LPM to proper skeletal patterning, we are employing a tissue-specific knockout of *Hoxa5* driven by Prx1-Cre. Embryos with this conditional deletion are collected and compared to both wild-type and *Hoxa5* loss of function embryos for skeletal phenotypes, including homeotic transformations. We hypothesize that the patterning of skeletal elements derived from the LPM or interacting with LPM-derived tissues during development will be disrupted by the conditional deletion. *Hoxa5* expression in the LPM is also thought to contribute to respiratory function which is compromised in *Hoxa5* loss of function mice, and thought to explain their death at or shortly after birth. Therefore, we will also analyze the survival of the tissue-specific mutants.

11. Assessing the Neuroprotective Effects of Statin Drugs: A Meta-Analysis

Joanly Sanchez
Mentor: E. Sander Connolly and Brandon Christophe
Department of Neurosurgery, Columbia University Medical Center

Statin drugs, well known for their lipid lowering capabilities and reduction of cardiovascular disease, have repeatedly been found to be neuroprotective after a stroke in both retrospective clinical studies and studies utilizing animal models. In our study, we have conducted a meta-analysis of available publications that evaluate this observation. Through a constructed search term, 119 publications that evaluated the role of statins after a stroke were identified. A total of 24 articles were chosen for final use in the meta-analysis based on selected inclusion criteria. The effect size was evaluated by the Weighed Standardized Mean Difference approach and the statistical methodology used includes performing a series of multivariable regressions. Meta-regression analysis was used for our broader meta-analysis, testing the effect of statins vs. no statins as treatment after the induction of ischemic stroke, and for our stratified meta-analysis that evaluates the effect of statin type and other influencing variables on the following outcomes assessed: infarct, edema formation, BBB (blood brain barrier) breakdown, and functional outcome (as measured by neurological function evaluations). Our meta-regression shows that the use of statins as treatment after ischemic stroke does significantly provide improvement of outcomes, Pravastatin having the greatest effect($P=0.000478$). This was also consistent when observing infarct and functional outcome alone. When observing all variables under all outcomes, IV and SC injections as modes of administration had the greatest effect($p<0.001$). Our analyses provide further evidence of the efficiency of statin drug's neuroprotective capabilities but also give insight as to which variables optimize statin's neuroprotective effects.

12. Quantification of Gait Parameters in Mice with Niemann-Pick Type C Disorder

Joo Won Kang
Mentor: Stephen L. Sturley
Department of Genetics , Columbia University Medical Center

MouseWalker is a recently developed software that quantifies motor performance in murine models. A quantitatively based, statistically accurate approach to studying gait and coordination is essential to understanding the progression of neurodegenerative disorders where mobility deteriorates. It is also important in observing the effects of new treatments. Using video monitoring and optical techniques coupled with the MouseWalker program, we analyzed and measured the gait in mice with the neurodegenerative lysosomal storage disorder Niemann-Pick Type C (NPC). To establish the efficacy of the MouseWalker program, data analysis was done on video recordings of control mice and the Npc1 null homozygotes NPCnih (-/-) and NPCnmf models, starting at a young age. The mice were video recorded walking across two surfaces, an open platform, and a maze. While the open platform provided an unobstructed space to view the gait of the mice, the maze system added the possibility to also assess the cognitive function of the mice. The program will be able to extract various parameters to describe the locomotion of the mice over time, as the mice with Niemann-Pick Type C begin to exhibit motor impairment.

13. CD4+ T cell force generation in female vs. male immune response

Julia S. Pickel
Mentor: Chirag Sachar[1], Lance Kam[1], and Morgan Huse[2]
[1]Department of Biomedical Engineering & [2]Sloan Kettering Immunology Program
[1]Columbia University and [2]Memorial Sloan Kettering Cancer Center

Female and male immune systems are typically not distinguished by researchers and clinicians in studies and trials. However, differences in female and male immune systems have become evident: innate and adaptive immune responses, reaction to medication, risk of autoimmune disease, and susceptibility to immune disease have each been shown to exhibit sex-based differences. These differences influence the way the immune system and immune disease are studied as well as how researchers and clinicians approach disease. Further, reactions to drugs aimed at diseases affecting the immune system have shown sex based differences due to underlying immune system differences. T cells play a key role in the immune system and in applications of immunology such as immunotherapy. T cells are known to exert mechanical forces in T cell signaling and the immune response. These forces impact the strength of the immune response and T cell expansion. Our experiment sought to investigate the role of sex-based differences in the forces generated by CD4+ T cells. Forces generated by blasted and naïve mouse T lymphocytes were determined using a microscale elastomer pillar array. Pillar deflection was used as a quantitative measure of force generation in order to compare T cell force generation in male vs. female mouse CD4+ T lymphocytes.

14. Exploring N. ceranae infections in A. mellifera colonies

M. Tasnin Kabir , Laure Raymond, Jean Paul Salinas
Mentors: Jonathan Snow
Department of Biology, Barnard College

Over the past decade, honey bee colonies have been experiencing a phenomenon known as Colony Collapse Disorder (CCD) in which the worker bees in the colony perish. This poses a problem because without the workers to bring back pollen and nectar, the colony will not survive nor can they help to pollinate our crops. When investigating the root of the problem, it has become evident that there is no singular cause with a combination of causes including chemical toxicity, infectious agents, habitat loss, and industrial beekeeping practices. *Nosema ceranae* (*N. ceranae*) is a microsporidian whose life cycle has yet to be fully characterized, but has been found to infect *Apis mellifera*, the European honey bee found in the U.S. This highly evolved fungus gives rise to infectious spores that contaminate the bees' water source and proliferate in the cells of the bee's midgut once ingested causing individual disease and colony collapse. Our work seeks to 1) explore the effects that redox stress has on the *N. ceranae* infections by using drugs known to induce such stress in bees (DTT and Paraquat) and 2) attempt to define a cell line to build a cell culture model to further investigate *N. ceranae* in hopes of better understanding the microsporidia and potentially develop treatment strategies.

15. Point Mutation Affects the Stability of Spectrin Alpha Subunit

Sophia Loo
Mentor: Julio Fernandez
Department of Biological Sciences, Columbia University

Spectrin is a cytoskeletal protein found in eukaryotic cells. This protein is essential in the maintenance of the biconcave shape of red blood cells, while also providing the cell with elasticity. Spectrin is made up of an alpha and beta subunit, which come together to form a heterodimer. These heterodimers can also bind in a head-to-head conformation to form a tetramer. Various blood disorders, such as elliptocytosis, are a result of a single point mutation in this protein. The mutation causes the heterodimer to spend more time in a closed formation, and therefore prevents the formation of tetramers. This in turn affects the shape and stability of red blood cells. It is hypothesized that the mutation results in a kink in the alpha subunit, conformationally predisposing the subunit to bind to its beta subunit counterpart. While this is a possibility, we instead think that the mutation results in a weaker alpha subunit that is more prone to unfolding. Because the alpha subunit is more flexible when unfolded, it has a higher chance of bending into the conformation required for binding to the beta subunit. Using single molecule experiments, we are studying the stability of spectrin both with and without the point mutation. We are doing so by expressing a spectrin construct prepared for the use of magnetic tweezers, and applying force ramps to compare the force at which the protein unfolds in mutated and non-mutated versions of the protein.

16. unPAK's phytometers: Calibrating environmental and phenotypic variability from a plant-centric perspective

Meaghan Marohn
Mentor: Hilary Callahan
Department of Biology, Barnard College

Arabidopsis thaliana is a widely used model organism in genetics, molecular and developmental biology, and plant ecology. In addition to natural accessions, vast mutant libraries exist, with the SALK T-DNA knockout mutant library among the most comprehensive and the focus of Undergraduate Phenotyping of Arabidopsis Knockouts (the unPAK project), a genome-wide investigation of how frequently mutations affect plant fitness traits. Over the last five years at Barnard's campus, nine growth chamber experiments have been completed, each analyzing 122 unique SALK mutants, totaling over a thousand genotypes. Though unPAK is motivated by the genomic importance of Arabidopsis, it also aims to understand how environmental variation affects the relationship between genotypic and phenotypic variation. To do this, all experiments include a non-mutant wild-type and ten Arabidopsis ecotypes from different parts of Arabidopsis' native range, referred to as phytometers. I analyzed environment-dependent differences in trait means for phytometers grown in two experiments conducted in the Barnard greenhouse. Plants in the 2016 experiment were nearly half the 2017 mean across traits measuring plant size, while days to bolting and average fruit length showed less drastic variability. Additionally, trait means from growth chamber experiments generally fell within the range of the two greenhouse experiments. The utility of including ecotypic references in each experiment is well demonstrated by the wide range of phenotypic variability not only across different environments (greenhouse vs. chamber) but also across seemingly similar environments (consecutive chamber experiments).

17. Regulation and function of the NO-cGMP pathway in Drosophila sensory neurons

Natalie K. Kolba
Mentors: Wesley B. Grueber
Department of Neuroscience, Columbia University

The cyclic guanosine monophosphate (cGMP) pathway is a conserved signaling pathway (Denninger & Marletta, 1999). cGMP is generated by soluble guanylate cyclase (sGC) when sGC is bound by the gaseous neurotransmitter nitric oxide (NO). Cells that respond to exogenous NO donors by upregulating cGMP are therefore termed "NO-sensitive". NO-sensitivity varies widely in different cells, but it is not known how sensitivity, or a cell's use of the cGMP pathway, is controlled. I am exploring how cGMP signaling is controlled in neurons of *Drosophila melanogaster*. I confirmed that sensory neurons with different functions have different NO sensitivities. Class I sensory neurons show strong NO-sensitivity and class III touch receptors are NO-insensitive. To test whether NO-sensitivity was related to the levels of sGC expressed by sensory neurons I labeled sGC-expressing cells using an sGC-GFP fusion protein. I found that levels of sGC are high in class I neurons and absent in class III neurons, consistent with the distinct NO sensitivities. I next hypothesized that the levels of sGC may be regulated by the Cut transcription factor, as Cut is differentially expressed in class I and class III neurons. This was tested by examining sGC-GFP levels and NO sensitivity in flies that overexpress Cut in class I neurons. It was found that Cut decreases sGC expression and suppresses NO sensitivity in class I neurons relative to wild-type controls. Because Cut has known roles in neuronal morphogenesis of sensory neurons, I will next explore possible roles of cGMP signaling in Cut-regulated sensory neuron development.

18. The Role of Notch signaling in trophoblasts

Nicki Mohammadi
Mentor: Nataki C. Douglas
Department of Obstetrics, Columbia University Medical Center

Trophoblasts are important cells that contribute to placentation. The Notch signaling pathway is critical for the development of the placenta. Therefore, we hypothesize that inhibition of Notch signaling in trophoblasts will affect the ability of trophoblasts to differentiate and will result in abnormal placenta formation, fetal growth compromise and miscarriage. In this study we use Cre-LoxP technology to determine the role of Notch signaling in trophoblasts. Cyp19-Cre is a cre recombinase specifically expressed in trophoblasts. We used Dominant Notch Mastermind-like (DNMAML), which is a truncated form of the canonical MAML portion of the Notch pathway, to inhibit Notch signaling. Mice expressing Cyp19-Cre; DNMAMLflox/flox will not have Notch signaling in trophoblasts. We used Cyp19-Cre; RosaLacZ flox/flox mice to confirm that Cyp19-Cre is expressed in trophoblasts and thus understand where Notch signaling is deleted. We sacrificed pregnant Cyp19-Cre; DNMAMLflox/flox female mice and control mice at embryonic days 14.5, 16.5 and 18.5 to determine how deletion of Notch affects the development of the placenta and fetus. We recorded fetal and placental weights. We processed placentas to assess morphology. Our data suggests that a loss of Notch signaling in trophoblasts does not affect fetal development, fetal weight or placental weight. These preliminary conclusions may be due to a small sample size and the fact that gender was not incorporated into our analysis. We are currently determining genders. We are analyzing placentas to determine if there are any morphological differences between mutants that lack Notch signaling in trophoblasts and controls.

19. Fusobacterium nucleatum and Intestinal Pathogenesis

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Intestinal permeability has been studied to be associated with a wide variety of chronic inflammatory diseases including celiac disease, Crohn's disease, and as established more recently, obesity and other metabolic conditions. The intestinal barrier refers to the function of the intestine in shielding bacterial invasion; it exists as a single layer of epithelial cells and the tight junctions between them, which include protein complexes of occludins and claudins. *Fusobacterium nucleatum* (*Fn*), a gram negative oral commensal bacteria, has been associated with a range of intestinal diseases due to its invasive capabilities and its tendency to turn pathogenic when given the opportunity; for example, certain strains of *Fn* have been found in elevated levels in the gut mucosa of patients with Irritable Bowel Syndrome (IBS). The Han lab has previously established that *Fn* is able to permeabilize a layer of endothelial cells via the FadA adhesin, one of its key virulence factors. Drawing on this model, we investigated whether *Fn* would be able to permeabilize a monolayer of the epithelial DLD1 cell line. Additionally, we hypothesized that since *Fn* expresses more FadA in the stationary phase than in the log phase, stationary phase *Fn* should be more successful in permeabilizing the monolayer. Our preliminary findings support this hypothesis, warranting further investigation of how *Fn* is able to permeabilize the intestinal barrier. This study could facilitate the production of new and novel therapies for these diseases, as well as establish a model to better understand the relationship between bacteria and pathogenesis.

20. Rescuing Chromatin: The Identification of Mutations in Schizosaccharomyces pombe that Rescue Heterochromatin Stability from Epe1 Overexpression

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Genetic sequences alone do not define cell status or determine cell status. Heritable chemical modifications on DNA and histones are instrumental in determining phenotypes. These include DNA methylation, which leads to silencing, acetylation, which leads to expression, miRNAs, and histone modifications. Histones are key protein components of chromatin; DNA winds around them. Chromatin exists as euchromatin and heterochromatin; heterochromatin is denser with suppressed gene activity, while euchromatin is lightly packed and usually actively transcribed. Modifications to heterochromatin have been shown to be epigenetically heritable. This research focuses on the overexpression of the gene *epe1* in *Schizosaccharomyces pombe*, which leads to instability of heterochromatin, and thus there is heritable expression where there should be silencing. *Schizosaccharomyces pombe* (fission yeast) was chosen as a model organism due to its epigenetic simplicity and large heterochromatic centromeres that are beneficial for studying the silencing mechanisms. The purpose of this study was to identify gene deletions in *S. pombe* that lead to chromatin rescue despite epe1 overexpression. This was accomplished through crossing strains of *epe1* overexpression *S. pombe* with strains with a single gene deletion, and evaluating whether a *ura4* marker placed within the heterochromatin was expressed.

CHEMISTRY

21. Synthesis of 1,2-Cis 2-Amino Oxazolidinone Sugars for Use in Drug Development

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Mentor: Christian M. Rojas
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Glycodiversification is one means to assemble a library of potential drug candidates, and involves varying only the sugar attachments on drug scaffolds to produce differing bioactivities from one analogue to the next. For example, this approach could be used to discover new drug candidates to address the dearth of available treatments in cases of infections by antibiotic-resistant bacteria. Our group's recent focus has been on the optimization of various pathways to achieve stereochemically diverse 2-amino sugars for use in glycodiversication studies. The aim of this project is to optimize the synthesis of the 1,2-cis (β) anomers of these 2-amino sugars, in order to increase the stereodiversity of our sugar library. Commercially available D-glucal was used to create a 4*O*,6*O* protected 3*O*-*N*-hydroxycarbamate. Selected benzoyl derivatives were attached to the hydroxyl position of the carbamate, resulting in *N*-benzoyloxy carbamates that were used for intramolecular amidoglycosylation, a reaction in which a 2*N*,3*O*-oxazolidinone ring formed and the benzoyloxy group was installed at the *C*1 position. Two different approaches were used for this process: (1) an iridium catalyst and photoredox chemistry, and (2) a ligated iron(II) catalyst to generate a metallanitrene intermediate. The reactions yielded the glycoside products (both the α and the β anomers, with an excess of the β anomer) that could be utilized in glycodiversification reactions. In ongoing work, our group seeks to further increase the diastereoselectivity and chemoselectivity of these reactions to optimize the synthesis of the desired 1,2-cis glycoside product.

22. Optimization of metallothionein-3 purification and identification of secondary structure

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Mentor: Rachel N. Austin
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The primary purpose of this project is the examination of the secondary structure and behavior of metallothionein-3 (MT3) in the presence of heavy metals, specifically lead and zinc. This interest is in part inspired by two unknowns; the mechanism of lead poisoning and the regulation and function of metallothionein-3. Lead poisoning is an acute or chronic condition caused by a buildup of lead in the brain. Lead exposure is especially harmful to the brains of developing children and can lead to decreased IQ, learning difficulties, behavioral problems, and growth delays. Metallothionein (MT)-3 is a brain-specific member of the metallothionein family of cysteine-rich proteins that are involved in metal homeostasis and detoxification by binding to the metals such as zinc (Zn) and lead (Pb). Due to MT-3's possible role in metal detoxification and its location in the brain, it may be involved in modulating neuronal lead levels.The current work optimizes MT-3 purification, specifically the thrombin cleavage step, in order to obtain accurate secondary structure of MT-3 bound to each metal. Using circular dichroism (CD) spectroscopy, we monitor changes in MT-3 structure when bound to Pb rather than Zn. This work will lead to a better understanding of the role of MT-3 in lead poisoning.

23. Effects of the formin inhibitor SMI-FH2 on Delphilin and DIAPH1

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Formins are a highly conserved family of multi-domain proteins involved in cell motility, cytokinesis, actin polymerization, and microtubule stabilization. The disruption of these processes has been implicated in cancer and other diseases. Formins may therefore be involved in their onset and progression. However, the specific functions of different formins remain unknown. The recent identification of SMI-FH2, a small molecule inhibitor of formin-mediated actin assembly, has laid the foundation for understanding how these proteins function in cells and raised the possibility of therapeutic targeting of formins. This project seeks to elucidate the effect of SMI-FH2, along with a panel of diverse homologs, on the activities of several human formins. We have focused initially on Delphilin and DIAPH1 formins. As Delphilin isn't inhibited by the intramolecular interaction typical of other formins, SMI-FH2 may be useful in probing its regulatory mechanism. Mutations of the formin DIAPH1 have been associated with DFNA1, a form of degenerative hearing loss. In preliminary experiments, an altered rate of actin polymerization was observed in the presence of SMI-FH2. As SMI-FH2 is an inhibitor of formin homology 2 (FH2) domains, it should theoretically have no effect on actin in the absence of formin. *S. pombe* profilin, a small and ubiquitous actin-binding protein, was therefore purified to establish a new negative control. The inclusion of this third variable increases physiological relevance of our data and prevented the inhibitory effect of SMI-FH2 on actin polymerization. Our successful establishment of this control condition will allow us to determine the effect of SMI-FH2 on various functions of Delphilin and DIAPH1 in the future.

24. Autoinhibition in mutants of the formin protein DIA1

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Department of Chemistry, Barnard College

The human formin DIA1, encoded by the gene DIAPH1, both nucleates and catalyzes the growth of actin filaments. Regulation of DIAPH1 occurs through an autoinhibitory interdomain interaction between the diaphanous inhibitory domain (DID) in the N-terminal (NT) region and the diaphanous autoregulatory domain (DAD) in the C-terminal "tail" of the protein. This interaction inhibits actin polymerization activity. Mutations of DIAPH1 have been associated with autosomal dominant sensorineural hearing loss, but the mechanism of the hearing loss linked to DIAPH1 mutations has not been determined. Some have hypothesized that the mutated proteins are constitutively active due to loss of the DID/DAD interaction. This research aims to measure the strength of this interaction for three different DIAPH1 mutants: DFNA1, 1203X, and M1189D. The DFNA1 and 1203X mutants are associated with sensorineural hearing loss and the 1203X is associated with macrothrombocytopenia. The M1189D mutant protein has been shown to have dramatically reduced DID/DAD interactions compared to the wild type protein. There are three components to this project. First, the interdomain interactions will be qualitatively assessed using a yeast two-hybrid screen. Second, the affinity of the mutant tails for the NT domain will be assessed based on the rate of polymerization of fluorescently labeled actin. Third, a binding assay will be performed using fluorescence anisotropy measurements. The results of these assays will permit calculation of an equilibrium dissociation constant for each mutated tail from the N-terminus regulatory domains.

25. Porous Napthalenediimide-Based Materials for Fluoride Sensing in Water

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Department of Chemistry, Barnard College

Fluoride sensing is valuable due to the health benefits of fluoridated drinking water; however, because of the risks associated with overexposure there is room for improvement in current technology that exists for measuring fluoride concentration in water. The main goal of our project is to develop a chemiresistive sensor capable of selectively detecting fluoride anions in aqueous solutions. Our experimental approach uses napthalenediimide ligands (NDIs) and metal salts to create self-assembled metal organic frameworks (MOFs). MOFs are promising candidates for sensor materials because of their high degree of porosity and chemical tunability. Incorporation of NDI ligands into a porous MOF structure is expected to allow for a specific MOF–fluoride charge-transfer interaction, leading to selective fluoride sensing. Powder X-ray diffraction (PXRD) is used to characterize the crystalline structure of the MOF, as well as check for degradation after fluoride is introduced. We aim to prepare the MOF as a thin film on electrodes, in order to produce a quantitative readout of the electrical response to fluoride. Our research has three main steps to successfully create a fluoride sensing device: (1) synthesis and characterization of a porous NDI-based MOF capable of selectively binding with fluoride; (2) optimization of thin film growth of the MOF onto electrodes; and (3) developing a measurement procedure for quantifying the amount of fluoride present in water. This research may ultimately lead to an innovative approach to improving fluoride sensing technologies relevant to public health.

26. Purification and Characterization of AlkB Structure and Function in A. borkumensis and D. cinnamea

Sydney Hotz, Megan Ngai, Shoshana Williams
Mentor: Rachel Austin
Department of Chemistry, Barnard College

AlkB is an alkane monooxygenase responsible for the conversion of alkanes to their corresponding terminal alcohols. Millions of tons of alkanes are released into the environment each year through oil spills and natural seepage. Because these molecules are toxic to most organisms, AlkB is valuable for its ability to convert them to environmentally harmless alcohols.

This investigation aims to elucidate the activity and atomic structure of the diiron active site of AlkB from *A. borkumensis* and *D. cinnamea* through spectroscopic and crystallographic methods. In order to employ these techniques, the protein must be purified. Purification was facilitated by cloning and overexpression in *E. coli*. AlkB is a membrane-spanning protein, which makes its purification challenging, because it denatures and loses activity quickly in different environments. This challenge was addressed by using detergent micelles to mimic the cell membrane as the protein was isolated. A successful purification of AlkB from *A. borkumensis* was performed using an anion exchange column and a strep column. The activity of *D. cinnamea* was examined over a wide substrate range.

27. Synthesis of 2-Amino Oxazolidinone Reducing Sugars for Glycodiversification Studies

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Mentor: Christian Rojas
Department of Chemistry, Barnard College

As antibacterial resistance and a lag in drug discovery and development pose an increasing threat to public health, scientists are relying on what organic chemistry maestro Samuel J. Danishefsky has called the "awesome power of chemical synthesis" to develop novel drug candidates to mitigate this problem. Through glycodiversification, a process that creates derivatives of a known parent molecule by appending varied sugar groups, a library of potential drug candidates can be readily accessed. The glycosidic attachments can profoundly influence the bioactivity of the altered scaffold. As this approach is limited by the availability of varied building blocks, our group's recent focus has been the synthetic design and optimization of various pathways leading to stereochemically diverse 2-amino free-reducing sugars with additional functional groups. Amidoglycosylation was used to install a 2*N*,3*O*-oxazolidinone within the carbohydrate framework and incorporate a transient protecting group at the C1 position. The structure of these building blocks can be further diversified by cross-coupling an aryl group to the nitrogen of the oxazolidinone ring, as well as by incorporating an azide group at the C6 position. Subsequent deprotection, including at the anomeric site, produced the structurally diverse free-reducing sugars needed for glycosylation. Ongoing studies focus on exploring different neoglycosylation conditions, as well as utilizing different *N*-alkyl-*N*-alkoxyamines for this single-step coupling reaction with our free-reducing sugars.

28. Dinuclear Redox Chemistry with Rhodium and Silver Complexes

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Nature makes frequent use of dinuclear metal units to accomplish challenging multi-electron redox processes, especially for oxidative transformations. Both rhodium and silver complexes are useful catalysts for oxidation of organic molecules, and our research targets new redox chemistry that takes advantage of metal–metal interactions. Dimeric rhodium(II) complexes are good candidates for C–H oxidation catalysis because Rh(II)–Rh(II) bonds are known to react with O_2 to form peroxides or superoxides, which could potentially transfer oxygen to organic substrates. We have successfully synthesized, isolated, and characterized a new bipyridine-ligated Rh–Rh complex. We have observed reaction with oxygen under mild conditions, and are currently investigating the structure and reactivity of this new rhodium–oxygen adduct. Dinuclear silver complexes are promising as a cheaper alternative to precious metal catalysts for reactions such as C–N bond formation. However, understanding and improving reactions catalyzed by dinuclear silver complexes has proven to be difficult. We aim to isolate and characterize reactive intermediates in silver-catalyzed nitrene transfer reactions, using techniques such as single-crystal X-ray diffraction and Extended X-ray Fine Structure (EXAFS) analysis. Key questions include the oxidation states of the silver metals, and whether or not both silvers are involved in oxidation chemistry. Toward these goals, a new silver nitrene complex has been isolated.

29. Cooperative Reductive Intercalation of Metal-Chalcogenide Fullerene Solid-State Materials

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Metal-chalcogenide fullerene solid-state materials are self-assembling superatomic materials with exciting structural, magnetic, and electronic properties. Previous work has characterized the intrinsic charge -transfer from $Co_6Te_8(PPr_3)_6$ to three fullerenes in $[Co_6Te_8(PPr_3)_6][C_{60}]_3$, as well as oxidative intercalation with TCNE, but reductive intercalation of these materials has so far been elusive. In this study, the cooperative reductive intercalation of $[Co_6Te_8(PPr_3)_6][C_{60}]_3$ with TCNQ and alkali metals was investigated using micro-Raman spectroscopy. The Raman active $A_g(2)$ mode in fullerenes was used to determine the extent of charge-transfer between the fullerenes and the clusters and TCNQ. The $A_g(2)$ mode shifts 6 cm^{-1} per electron transferred to C_{60} from its value in pristine C_{60} of 1470 cm^{-1}. In order to generate reductive intercalation of $[Co_6Te_8(PPr_3)_6][C_{60}]_3$, we first intercalated the metal-chalcogenide fullerene host material with TCNQ in acetonitrile. After the initial intercalation, we observe a Raman shift from 1467.7 ± 0.7 cm^{-1} to 1468.7 ± 0.6 cm^{-1}, showing that the C_{60} is oxidized to its neutral state because TCNQ is reduced to form $TCNQ^-$ in situ. Separately, $TCNQ^{2-}$ is generated from $TCNQH_2$ and 5 equivalents of alkali metal acetates in DMF. These solutions are subsequently used to treat the metal-chalcogenide fullerene intercalation compound. After 3 days, we observe Raman shifts at approximately 1466 cm^{-1} with all alkali metal acetates, which indicates reduction of the C_{60} relative to the pristine sample. We will further investigate the dependence of the reductive intercalation of $[Co_6Te_8(PPr_3)_6][C_{60}]_3$ on the bases, reducing agents, and solvents used.

30. Towards a rational understanding of the mechanism of direct deoxygenation catalysts for biofuels upgrading

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The mechanism by which the catalytic deoxygenation of phenol occurs using a catalyst of ruthenium nanoparticles on titanium dioxide support was identified. Experiments were done with a range of synthesized heterogeneous catalysts to explore the effect of heteroepitaxy, the role of the noble metal, and the possibility of substituting more earth abundant metals for some ruthenium. Materials were characterized by a range of techniques including high resolution transmission electron microscopy, X-ray photoelectrospectroscopy, fourier transform infrared spectroscopy and X-ray diffraction. Density functional theory calculations done by collaborators provided additional mechanistic insights. Heteroepitaxy is not be important in generating active catalysts while contaminant-free surfaces that maintain active surface hydroxyls are critical. Further work needs to be done to find an earth abundant metal that is an effective direct deoxygenation catalyst.

31. Quantification of Mitochondrial DNA Lesions via Long-Amplicon Quantitative Polymerase Chain Reaction

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Mitochondrial DNA (mtDNA) is maternally heritable genetic information that has been implicated in the development and progression of many diseases, including diabetes mellitus and deafness, Alzheimer's, Parkinson's, and Huntington's diseases, aging, and the development of certain cancers. Sites of mtDNA damage, or DNA lesions, can limit or block the ability of DNA polymerase to bind to genetic information, preventing or decreasing the frequency of DNA replication. The quantitative polymerase chain reaction (QPCR) assay takes advantage of some types of mtDNA lesions' ability to block polymerase and can quantitatively measure the number of polymerase-stalling lesions relative to a population average.

The task was to explore areas of potential error to optimize a protocol that reliably and precisely quantifies the number of lesions on a fragment of mtDNA. By adjusting the parameters of the long-amplicon PCR reaction, such as annealing temperature, number of cycles, and extension time, we hoped to create an efficient method of quantifying lesions. While the optimal parameters of the PCR reaction remain unknown, several adjustments have been made to the protocol that have allowed for more accurate results. The current protocol provides information on relative lesion frequency comparisons between healthy and non-healthy individuals, allowing for a better understanding of epigenetic influences of disease.

32. Reactivity and Dynamics of Chlorocarbene Additions to Dibenzocyclooctyne

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The Merrer group uses experimental and computational approaches to investigate the reaction mechanisms of carbene additions to strained C-C π bonds. We are currently studying phenylchlorocarbene (PhCCl) additions to dibenzocyclooctyne (**1b**, DIBO), dibenzocyclooctylvinylcarbene (**2b**, DIBO-VC), and dibenzocyclooctylcyclopropene (**3b**, DIBO-CP) (Scheme 1). Experimentally, we have observed the photochemical addition of two equivalents of PhCCl to DIBO to form three isomeric products, **A-C**, at 350 nm. We are attempting to grow X-ray-quality crystals to definitively characterize the major product, **B**, which was also generated via sequential photochemical [2+2] cycloaddition and ring opening reactions at 254 nm. We are pursuing alternative synthetic routes to **A**, **B**, and/or **C** via microwave synthesis and/or Wittig chemistry. Experimentally, we are also synthesizing diazirine **9b**, which we expect will generate DIBO-VC (**2b**) upon irradiation. To this end, we are modeling the dibenzocyclooctyl system with the open-chain diphenyl system (Scheme 2). We have successfully synthesized **7a** in the route to diazirine **9a**. Our current computational work explores the possible structures of product **B** using density functional theory (B3LYP/6-31G(d) and M06-2X/6-31G(d)). We have also used density functional theory to compute the closed- (singlet) and open-electron-shell (singlet and triplet) pathways of the rearrangements of vinylcarbene **2a** to cyclopropene **3a**, cyclopentene product **4a**, and allene **5a** (Scheme 1).

33. Reactions of Group 4 Diene Complexes with Isonitriles

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We are interested in the insertion reaction between isonitriles (RNC) and diene complexes of hafnium (Hf) with a constrained geometry (CG, a linked tetramethyl-cyclopentadienyl-silyl-amido ligand) platform. Previous study showed that such reaction yields two double insertion products: a cyclopropane-fused cyclopentene complex and a 4,5-dimethylcyclohexa-1,4-diene complex. In this context, we found that the selective formation of individual product could be achieved by the different addition sequence of reagents. NMR analysis indicated that addition of the 2,6-dimethylphenyl isonitrile to (CG)Hf(2,3-dimethyl-butadiene) gave 92% of the cyclopropane product, while the reverse addition yielded >95% of the 4,5-dimethylcyclohexa-1,4-diene product. We then investigated the same reactions with ^{13}C-labelled isonitriles, with the aim to gain more insight into insertion mechanism. We confirmed that the two adjacent carbons on the cyclopropane ring arise from the isonitrile and the δ bond between these two carbons is activated by its coordination toward the Hf metal center. The degree of such activation could be probed by monitoring the reduction of the $^{1}J_{cc}$ coupling constant relative to that of free cyclopropane (12.4 Hz). With the two different isonitriles (2,6-dimethylphenyl isonitrile and ^{t}BuNC) that we studied, we were able to determine $^{1}J_{cc}$ (3.5 Hz for ^{t}BuNC and 6.8 Hz for 2,6-dimethylphenyl isonitrile, respectively) of the corresponding cyclopropane complexes.

34. Vibrational and Electronic Structure of Nanomaterials: from Molecular Clusters to Graphene

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We use resonance Raman spectroscopy to study the vibrational structure of metal atom linked hexaruthenium carbonyl clusters and computational chemistry to analyze graphene electron-transfer processes. In the first project, we use resonance Raman spectroscopy to investigate how the vibrational structure evolves as the chain length of hexaruthenium carbonyl clusters linked by Cd or Hg atoms increases and if electronic states are delocalized across the entire chain. Promising initial low frequency Raman measurements of the monomer and Hg dimer show distinctive peaks below 300 cm-1 that differ between the two samples and will be further analyzed with a temperature dependent study. In the second project, we investigate the results of a previous Raman study that showed that more electron transfer from graphene to iodine occurs in cyclohexane than in benzene. We have successfully optimized a graphene fragment with 120 atoms and a band gap of 1.7 eV. Our computational study will investigate the interactions of these solvents with graphene and iodine to understand why more electron transfer occurs in cyclohexane than benzene.

35. Gas-Phase Graphene Photochlorination Dynamics

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Graphene is a zero bandgap semiconductor, which makes it desirable for electronic applications. However, graphene lacks the bandgap needed to replace silicon as an electronic material. Reacting graphene with chlorine to produce chlorographene can produce this gap. We use Raman Spectroscopy to measure the effect of annealing on graphene photochlorination. A graphene sample is exposed to chlorine gas and irradiated by a 405 nm laser to generate chlorine radicals that react with graphene. As a result of this reaction, the carbon atoms in a photochlorinated graphene sample change from sp^2 to sp^3 hybridization. Graphene's D peak at 1350 cm^{-1} increases in intensity with greater sp^3 hybridization. By measuring the intensity ratio of the D peak to G peak at 1580 cm^{-1}, we can observe the photochlorination reaction kinetics. We perform these experiments on samples that have been annealed before the photochlorination process and for samples that have not. Annealing increases graphene's compressive strain which can be relieved in the photochlorination process. Initial results show no conclusive effect of the annealing on the photochlorination rate. However, the addition of spacers that raise the graphene samples above the cuvette face increases the photochlorination rate. Raman spatial maps show that photochlorination is localized where the graphene is irradiated with 405 nm light.

36. Excess Metal Exposure and Altered MiR-15a Levels as Regulators of MAPK3 and Tau Hyperphosphorylation

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Alzheimer's Disease (AD) is a neurodegenerative disorder characterized by the progressive loss of neurons resulting in symptoms that include loss of memory, decline of cognitive functions, and dementia. Two pathological events are thought to cause AD: the accumulation of extracellular amyloid plaques and the formation of intracellular neurofibrillary tangles (NFT). Aberrant cleavage of amyloid precursor protein (APP) contributes to beta amyloid formation and plaque deposition while hyperphosphorylation of tau contributes to its aggregation into NFT. Mitogen activated protein kinase 3 (MAPK3) is one of the kinases associated with hyperphosphorylation of tau protein and NFT formation. Additionally, AD brains have been linked to a buildup of excess metal ions such as copper(II) and dysregulated microRNA such as miR-15a which contributes to posttranscriptional regulation of gene expression of the 3' untranslated region (3' UTR) of MAPK3. Preliminary work in MAPK3 3' UTR reporter constructs treated with 100 μM copper (II) showed increased luciferase expression relative to non-treated controls. Current research investigates the effect of copper(II) treatment on MAPK mRNA and total and phosphorylated protein levels in non-reporter cells. Results showed that SHSY5Y and U87 cells treated with copper(II) led to increased MAPK3 mRNA levels and an increase in phosphorylated MAPK3 protein levels. Further experiments will focus on quantifying total and phosphorylated tau protein. The effects of metals and miRNA mediations on gene regulation in neuronal cells will lead to a better understand the mechanism of hyperphosphorylation of tau through the MAPK pathway in AD.

37. Radical Cyclizations Catalyzed by $[NEt_4][CpV(CO)_3H]$

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Carbon-centered radicals have traditionally been generated from the reaction of alkyl halides with trialkyltin hydrides. Although the tin hydrides are synthetically useful (i.e. in radical cyclizations), the resultant trialkyltin byproducts are toxic, prohibiting the use radical chemistry on industrial scale. Additionally, the trialkyltin hydride is inherently wasteful, generating an equivalent of Bu_3SnX waste per equivalent of H•.

In response to the clear need for alternative sources of H•, the Norton Group has studied a series of first-row transition-metal hydrides. After H• transfer, some hydrides can be regenerated from H_2 (in other words, used catalytically). Such hydrides often have weaker metal-hydrogen bonds than the metal-hydrogen bond of Bu_3SnH, making them more effective H• donors than tin. These hydrides were therefore unsuitable for generating radicals as tin does, i.e. from alkyl halides.

The vanadium hydride anion $[CpV(CO)_3H]^-$ was first disclosed as a stoichiometric alternative to the tin hydrides by Robert Bergman. We have expanded on these studies, and have found a way of making the reactions of this hydride catalytic under H_2 (by adding DBU). $[CpV(CO)_3H]^-$ is thus a direct and catalytic replacement for the trialkyltin hydrides.

38. Bridging the Connect: Supercharged GFP as a Scaffold for the Channeling of Glucose-6-Phosphate Between Hexokinase (HK2) and Glucose-6-Phosphorylate Dehydrogenase (G6PD)

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Substrate channeling, a mechanism widely existent throughout nature, enables intermediates between a cascade of enzymatic steps to be directed through a micro-compartment between two enzymes, the enzyme producing an intermediate and the one receiving it. The use of a substrate channel prevents the intermediate metabolic product from becoming dispersed into the rest of the solution, thus increasing efficiency between enzymatic steps of the metabolic process. Ample examples of substrate channeling are found in nature that use different biochemical mechanisms of transporting the intermediary product from one enzyme to the next. Notably, the mechanism of substrate channeling through electrostatic guidance, or the use of opposite charges to move an intermediary through a charged micro-compartment, exhibits potential for the manufacture of a supercharged channel protein, Green Fluorescent Protein (GFP), that would bridge the connect between HK2 and G6PD. This would allow for its intermediate metabolic product, glucose-6-phosphate, to travel through the supercharged GFP scaffold, restricting its movement into the rest of the solution and only allowing it to travel to the next enzyme in the metabolic pathway, G6PD. Such a properly engineered scaffold would increase the efficiency of activity within the pathway, specifically optimizing the pentose-phosphate pathway, a metabolic pathway that functions parallel to the glycolysis pathway.

39. Selenium redox chemistry: from surface reactivity to biological applications

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Selenium is an essential trace element, primarily found in the amino acids selenomethionine and selenocysteine. Proteins containing selenocysteine in their active site are known to play an integral role in key physiological processes. Several fundamental questions remain, however, regarding the unique redox chemistry afforded by selenocysteine in the cellular environment. Using surface and solution electrochemical and spectroscopic techniques, the selenocysteine / selenocystine redox couple has been examined under physiological conditions at gold electrodes. Voltammetric behavior is indicative of a two-step process, in which the metallic substrate is modified by the diselenide analyte prior to observation of diffusionally controlled, proton-coupled electron transfer. X-ray photoelectron spectroscopy confirms the presence of selenium on electrochemically modified surfaces. The adsorbate can be removed via oxidative stripping or reductive desorption and subsequently regenerated, displaying high recyclability with little to no loss in signal restoration. Studies on these modified surfaces have extended to the cysteine / cystine redox couple, with particular interest in the reactivity between cysteine and selenocysteine. We have also begun to explore the voltammetric behavior of physiologically relevant chalcogenone ligands, including dimethylimidazole thione and dimethylimidazole selone. Electrochemical and spectroscopic characterization data on these systems will be presented and biosensing applications of our selenium-modified electrodes will be discussed.

ENVIRONMENTAL SCIENCE

40. Groundwater Chemistry of Deep Wells in Araihazar, Bangladesh

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Arsenic is a naturally occurring metalloid found in the sediments of many countries, including Bangladesh. In the 1970s, tubewells were installed to reduce the incidences of pathogen borne diseases from surface water. Although pathogen contamination lowered as a result, arsenic contamination from groundwater skyrocketed, exposing the population to high levels of arsenic. This is described as one of the largest mass poisonings in history. Today, between 35 and 77 million people in Bangladesh are chronically exposed to arsenic in drinking water. As an intervention, the government installed as many as 200,000 deep wells. Though these deep wells typically ensure lower levels of arsenic, little research has been done to evaluate their groundwater chemistry. The goal of this project was to examine the groundwater chemistry by looking at cations (As, Fe, and Mn) and anions (Cl^- , Fl^- , SO_4^{2-} , Br^-) found in the deep wells of Araihazar, Bangladesh and see how they stand against the WHO standards. The IC and ICPMS were used to detect 7 anions and 13-20 elements found in groundwater. We found that most deep wells are low in arsenic; however, manganese levels were almost as high as the SMCL and iron exceeded the SMCL. The low Cl/Br ratio indicates most of the wells have not been contaminated by human wastes. Interventions such as testing and installations of deeper wells can continue to help mitigate arsenic exposure and protect the drinking and irrigation waters of Bangladesh.

41. Should Columbia University Invest in On-Site Bio-Fuel Recovery? A Feasibility Assessment

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Is it economically feasible to recover bio-fuels from daily waste streams? This study specifically focuses on the feasibility of recovering bio-H_2 and bio-CH_4 on-site from food and human waste streams generated on the Columbia University main campus. With an estimated food waste of 1,185 kg/day and human waste of 11,576 kg/day at Columbia, a maximum of 2.32×10^6 kJ/day of bio-H_2 and 1.41×10^8 kJ/day of bio-CH_4 can be recovered. This represents a maximum cost recovery of $15,107/year and $277,425/year, respectively. The maximum bio-reactor volume required for the amount of bio-H_2 produced totals 319 m^3, representing an estimated total investment (ISBL and OSBL) cost of $85,791. For bio-$CH_4$, a maximum bio-reactor volume of 2,391 m^3 is required, representing an investment of $1,575,421. The payback period for bio-H_2 is 6.1 years, and for bio-CH_4, 10.4 years. With an internal rate of return (IRR) of 15.3% for bio-H_2, and 6.9% for bio-CH_4, both investments provide favorable economics driven by the off-set of natural gas purchases. Additional benefits could be achieved by recycling reactor waste effluent, such as off-set of soil fertilizer purchases and waste haulage costs. The IRR for both bio-fuels is most sensitive to the market value of the fuels (natural gas price) followed by the amount of bio-fuel production. Future work entails examining a larger scale NYC facility and smaller scale operations to support household and village-wide facilities in developing regions, where majority of rural homes rely on toxic and polluting fuels for energy needs.

42. A study on climate's effect on xylogenesis in Hemlocks, Oaks, and Red Pines in Black Rock Forest

Emy Metzger
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Department of Environmental Science, Barnard College

While tree-coring is a technique most commonly used to age trees, tree cores can also provide information about a tree's growth during a specific year of the plant's life. Annual growth can be determined by measuring the width from one tree ring to the next, and determining how much the tree had grown from the previous year. A tree's yearly growth depends largely upon temperature and precipitation, as well as its position in the canopy and basic health. While canopy position and tree health are constant factors, tree growth correlates positively with temperature and precipitation. A tree's growth occurs in the xylem, in which cells divide primarily during the spring season. In Black Rock Forest, electronic dendrometers are used to continuously measure specific trees' growths, thus providing data on current xylem cell division, or xylogenesis. Using the live feed data provided by the dendrometers in addition to microscopically viewing the most recent xylem cells in these trees, it is possible to correlate the trees' growth patterns with corresponding temperature and precipitation data in the area. Preliminary results show that precipitation increases tree circumference not only due to xylogenesis, but also temporary bark swelling from water absorption. With this understanding of how select trees are affected by temperature and precipitation, predictions can be made regarding how climate change, with warmer temperatures and altered precipitation patterns, will impact tree growth in the future.

43. Exploratory Analysis of Infant Mortality Rate Integration in Social Vulnerability Assessments for Drought Afflicted Mexican Livelihoods

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Infant mortality rate (IMR), among other health indicators, can serve as a useful measure of social stratifications of wealth and economic prosperity. This indicator can be used in composite indices, which have been applied in many human-environment studies and have played a significant role in decision making within the public policy arena. For Mexico, a historically drought afflicted country, indices can serve as multidimensional tools of analysis for measuring social vulnerability to drought events. The aim of this project is to combine the climate vulnerability index described in the Intergovernmental Panel on Climate Change's 2001 report and Dr. Susan Cutter's Vulnerability of Places model into a holistic framework to understand how drought affects Mexican livelihoods. We explore the influence of integrating IMR into a drought vulnerability index. IMR data for the years 2000 and 2014 were obtained from the NASA Socioeconomic Data and Applications Center (SEDAC). We developed a composite vulnerability framework featuring three subindices (sensitivity, adaptive capacity and exposure), where IMR is assigned to the sensitivity subindex. For comparison, we will use Principle Component Analysis (PCA) to inform the design of an alternative drought vulnerability index. ArcGIS will be used to visualize the results of this exploratory analysis.

44. Photoheterotrophy in *Prochlorococccus* and *Synechococcus* from the Southwest Tropical Pacific Ocean

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Lamont Doherty Earth Observatory , Columbia University

The photosynthetic cyanobacteria *Synechococcus* and *Prochlorococcus* are the most abundant marine microbes in the ocean, contributing significantly to the storage and cycling of biologically important nutrients as well as to overall primary productivity. It has recently been demonstrated that *Prochlorococcus* is also capable of heterotrophy which is the ability to uptake organic carbon and nutrients from the surrounding environment. The aim of this project is to examine to what extent *Prochlorococcus* and *Synechococcus* demonstrate photoheterotrophy and how light and nutrient availability impact the metabolic capabilities of these organisms. Samples were obtained from different depths and locations in the Southwest Tropical Pacific and inoculated with either ^{3}H-Glucose, ^{3}H-Leucine, or ^{3}H-ATP, representative of organic molecules with C only, C and N, or C, N and P, respectively, or with ^{14}C-sodium bicarbonate as reference for photosynthesis. The samples were incubated in photosynthesis irradiance incubators under varying light intensities, at *in situ* temperature. The samples were frozen and later processed in the laboratory to determine the amount of radioactive molecules assimilated by *Synechococcus* and *Prochlorococcus*. Using a flow cytometer, the samples were sorted into two populations of *Synechococcus* and *Prochlorococcus*, filtered using vacuum filtration, and then put into a Liquid Scintillation Counter which measured the radioactivity per sample. The radioactivity is used as a measure of carbon or nutrient assimilation in each population of cyanobacteria. The results will provide a better understanding of the photoheterotrophic capabilities of cyanobacteria and how significantly they contribute to the flux of organic matter in the ocean.

45. Organic Carbon, Nitrogen, and Sulfur Cycling Genes Present in Bacterial Communities from Arsenic Contaminated Bangladesh Groundwater

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Mentor: Brian J. Mailloux
Department of Environmental Science, Barnard College

Determining carbon, nitrogen, and sulfur genes utilized by active microorganisms in the environment is critical for understanding carbon, nitrogen, and sulfur cycling. A specialized RNA extraction and purification method has been developed to analyze the radiocarbon dating and nucleic acid sequencing of microbial communities found in groundwater from three different wells (B3, F4, and CAT) in Araihazar, Bangladesh that have been contaminated by Arsenic. Radiocarbon results from the extracted and purified environmental RNA indicate use of a carbon source that is 1875 ± 50 years old at site B3, 1435 ± 35 years old at site F4 and 5230 ± 70 years old at site CAT. These radiocarbon dates suggest subsurface microbial metabolism of organic carbon at these sites and potentially other arsenic contaminated groundwater wells in Bangladesh. Using a High Throughput Sequencing Database and a High Performance Cluster, genes from these sites have been identified that correspond with nitrogen and sulfur cycling. Thus far, the abundance of functional genes is associated with N-fixation, nitrification, and denitrification in the nitrogen cycle along with sulfate reduction and sulfur oxidation in the sulfur cycle. Ultimately, once the genes are understood and analyzed, metabolic pathways will be created for each of the sites.

46. Enterococcus in Sediment in the Hudson River at 125th Street in Manhattan NY

Sarah Ortiz
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New York City uses a combined sewer system and combined sewer overflow (CSOs) which release sewage and runoff from the streets into the Hudson River during large precipitation events. This project tracks enterococcus in Hudson River water and sediment. Enterococcus is the federally recognized indicator bacteria for fecal matter in sewage waste. The EPA standard for enterococcus in marine and fresh waters is 30 CFUs/100 ml but there is no EPA standard for enterococcus in sediment (#1). The Enterococcus Study Group has been tracking enterococcus in the water of the Hudson River for eight years but has just recently begun to investigate enterococcus in sediment. The goal of this project is to determine whether there is a significant amount of enterococci present in Hudson River sediment and, if so, to look for a correlation between enterococci in sediment and enterococci in water. Samples are collected from the 125th street pier and IDEXX enterolert and colilert are used to determine the number of colony forming units in each water and sediment sample. Enterococci were present in all water and sediment samples but no significant correlation was found between enterococci in water and enterococci in sediment for paired samples.

47. How In-situ and Exogenous Sources of Organic Carbon Cause Iron Reduction and Arsenic Release in Anaerobic Sediment-Groundwater Microcosms

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Groundwater arsenic contamination affects more than 100 million people in South and Southeast Asia. To determine who is affected and the best way to mitigate this contamination, we need to understand what controls arsenic levels in groundwater. Arsenic concentrations in water are usually high where microbes have reduced arsenic-bearing iron oxides as part of respiration; this respiration consumes organic carbon but we do not know which organic carbon substrates are most important to arsenic release. In this research, we examined anaerobic sediment-groundwater microcosms to determine how both in situ (sedimentary) and exogenous (from somewhere else) sources of organic carbon differentially cause iron reduction and arsenic release. The sediments were collected from two wells in the Red River Delta in Vietnam. We hypothesized that the concentrations of iron and arsenic released from sediments would be higher when there was an exogenous organic carbon source. The concentrations in microcosms containing no added carbon would also be significant. Two incubation bottles were prepared for each depth of the wells, the control (in situ) and the organic carbon (exogenous). We used sodium-lactate as the exogenous source of organic carbon. Each bottle had 5 grams of sediments in artificial groundwater. After acidifying samples, we measured trace elements concentrations using the Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and the dissolved organic carbon using the Total Organic Carbon (TOC) Analyzer. The decreasing oxidation-reduction potential suggests more arsenic may be released and more iron oxides may be reduced as time goes by.

48. Noctiluca scintillians response to varying concentrations of dissolved carbon dioxide in the Arabian Sea

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Noctiluca scintillians, or *Noctiluca,* is a large (500 and 1,000 mm in diameter) mixotrophic phytoplankton that has caused major restructuring of the Arabian Sea (AS) marine ecosystem since the year 2000. It is believed that the emergence of *Noctiluca* in various tropical oceanic systems is tied to the spread of hypoxia and the intensifying effects of global warming. Scientists and fishermen along the AS coastline have documented widespread fish kills which are directly attributed to outbreaks of *Noctiluca* blooms in recent years. The purpose of our study was to determine how varying atmospheric CO_2 concentrations and CO_2 dissolution in seawater impacts the health and development of *Noctiluca* throughout its growth cycle. The concentrations tested represent pre-industrial levels of atmospheric CO_2 (150ppm), current levels (400ppm), and projected levels (800ppm). We hypothesized that *Noctiluca* would perform best at 800ppm CO_2 because of its symbiotic relationship with *P. Noctilucae,* a photosynthetic endosymbiont which prospers in the acidic, low-oxygen conditions culminating today. Multiple parameters were tested during the experiment including: number of cells per experimental bottle, pH, oxygen, fluorescence, chlorophyll, nutrients, and ammonia for each of the respective treatments to track *Noctiluca's* rate of propagation and overall health. Our preliminary results were consistent with our hypothesis and indicate that *Noctiluca* prefer high CO_2, low-oxygen environments. These findings illuminate the possibility that *Noctiluca* will gradually overtake the AS region and continue to alter the AS marine food web in coming years.

49. Effects of crude oil on the balance of autotrophy and heterotrophy in the Hudson River Estuary

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Oxygen concentrations in estuarine water columns result from the balance of autotrophic and heterotrophic processes. Contamination by petroleum hydrocarbons is common in anthropogenically impacted coastal waterways, yet the effects of petroleum hydrocarbons on water column oxygen are difficult to predict because the hydrocarbons can be used as a carbon source by heterotrophic bacteria, but may also cause toxicity. Oil concentration and temperature are also likely to influence the outcome. In many aquatic environments, autotrophy and heterotrophic decomposition of oil are both nitrogen limited. However, N-limitation of either process is unlikely in the Hudson, given extremely high anthropogenic N-loading. To examine the effects of crude oil on the balance of autotrophy and heterotrophy in a nutrient-rich environment, experiments were conducted using water collected from the Hudson River Estuary from winter to summer. An emulsion of light, sweet crude oil was added to oxygen bottles at a range of concentrations (0-250 ppm), that were incubated at ambient temperatures (3-26°C) for ~2 d. The change in oxygen levels, heterotrophic bacteria, and phytoplankton chlorophyll in light and dark bottles was used to quantify the impacts of the oil additions on heterotrophy and autotrophy in the incubations. The fresh, crude-oil emulsion increased respiration and heterotrophic bacteria net growth rates, with stronger effects at higher oil concentrations. Potential autotrophy increased dramatically with temperature but there were also stronger toxic effects on autotrophs in warmer temperatures. These results indicate that oil pollution would shift the system more towards heterotrophy, and that the magnitude of the shift would be much larger at higher temperatures and oil concentrations, with greater likelihood of toxic effects on autotrophs at higher temperatures. The data also suggest that the Hudson is carbon, rather than nutrient limited.

50. The Agulhas Current: Shaping Human's Evolutionary Past and Predicting the Climatic Future

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The Agulhas Current, a western boundary current of the South Indian Ocean, flows southward along the coast of southern Africa. As the Agulhas current passes the tip of South Africa, it retroflects back into the Indian Ocean. Retroflection short-circuits periodically spawning warm, salty Indian Ocean water "leaking" into the Atlantic. South African climate change could affect the behavior, the nature, and quantity of sediments transported. Thus, reconstructing the provenance of sediments deposited by the current over time sheds light on how the current evolved and influenced global climate by participating in thermohaline ocean circulation (a process distributing heat globally). IODP expedition 361 collected sediment cores along the coast of South Africa dating from >4Ma - present, overlapping with key events of human evolution. Sediment cores show important climate events correlating with global climate records. To relate the composition in the cores to terrestrial climate conditions, it is necessary to characterize river sediments' compositions from the provenance. Eighteen South African sediment samples underwent autoclaving and sieving to separate the appropriate fractions. Mud was leeched in HH, rinsed, and freeze-dried for trace-metal analysis. Sand underwent density separation in LST (2.85g/cc), concentrating heavy minerals such as zircons, apatites, hornblendes. Minerals will be measured with mass spectrometer, quantifying the ages of their source rock. Combining chemical and geochronological information of samples with information recorded in cores from expedition 361 will answer questions such as climate change in South Africa, its role in human evolution, and behavior of the Agulhas Current over the Plio-Pleistocene period.

MATHEMATICS

51. A Computational Approach to Market Ecology

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On May 6, 2010 at around 2:45pm, the prices of publicly traded securities in the United States markets plunged and wiped out about a trillion dollars in value, only to recover in a matter of minutes. This "flash crash" and related extreme events have drawn attention to the increasing prevalence of algorithmic trading strategies in modern financial markets. In order to understand this new market ecology, we develop and explore a computational model in which multiple trading strategies interact to determine the dynamics of prices. In particular, we allow for long-term investors, information traders, and algorithmic market makers. We show that the distribution of prices in a market with only long-term investors has lower variance than the distribution of trader valuations: the market gives rise to price compression. Relative to this baseline level of volatility, adding information traders to the mix results in increased price dispersion. We then consider the effect of allowing for algorithmic market makers, who undercut and outbid the best available prices in the market in the expectation of profiting from the spread. These traders try to maintain directional exposure close to zero, and quickly reverse position whenever a directional limit is met. We examine how the optimal threshold and the strength of reversal vary with the rate and intensity with which news arrives, and examine the impact of such traders on the likelihood of extreme events such as the flash crash. The consequences of information trading and algorithmic market making on the welfare of long-term investors is also explored.

52. Development of Web Applications for Index Insurance and Risk Management

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Financial Instruments Sector Team, Columbia University

This project is a collaboration with Columbia University's Financial Instruments Sector Team, which provides climate index-based insurance and disaster risk management to farmers in developing countries. Prototype web applications generated via Flask, a web framework built with the programming language Python, were developed for deployment. For example, an earlier application contained a form requiring farmers to submit the central dekads, or ten day periods, in the early and late stages of their growing season, along with the five worst historical drought years. Using the programming language R, drought years submitted by farmers and index-based payout years were grouped by combinations of early and late central dekads; combinations with the most matches between the two variables were displayed in a table on the web application. Moreover, several other web applications were created. One contains seasonal monitoring forms, which gather information from farmers on soil and crop conditions, farming practices, the amount and timeline of local rainfall, and the rainfall and crop yield relative to past planting periods. To assess the effectiveness of their insurance, farmers were asked whether they received a payout that adequately covered their losses. Also, rain gauge measurements for rainy season dekads were collected. Another application contains a satellite data query form, which generates a CSV file with satellite data based on the location, month and satellite product submitted. Satellite products include CHIRPS, ARC2, and TAMSAT, which provide rainfall estimates, and vegetation indices NDVI and EVI. Additionally, an application was developed to collect information on risk management.

53. Symplectic Geometry: Understanding the Relationships Between 4-Dimensional Manifolds

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Mentor: Jo Nelson
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Here, we studied 4-dimensional symplectic manifolds with contact type boundary in order to refine understanding of the theory surrounding symplectic embeddings of one manifold into another. By definition, a symplectic manifold is a smooth manifold paired with a closed non-degenerate 2-form, called a symplectic form. A manifold is a space that locally resembles Euclidean space, or some set R^n. Because of this property, for any point on said manifold, the point is surrounded by a neighborhood where linear functions are well defined. A symplectic form measures 2-dimensional area on the manifold. A manifold can only be symplectically embedded into another manifold if it can be embedded while preserving its volume as well as this 2-dimensional area. The study of symplectic embeddings is important to modern research in geometry. This work has applications to Hamiltonian dynamics and classical mechanics, so the relationships found can be used to solve problems in physics. For my research, I examined the embeddings of polydisks, which are four-dimensional analogues to a cylinder, into four-dimensional spheres and ellipses. Similar results in this field include the proof of Gromov's non-squeezing theorem, which states that a sphere can only be symplectically embedded into a cylinder (or polydisk) if the radius of the sphere is less than the radius of the cylinder.

NEUROSCIENCE & BEHAVIOR

54. Do artificial sweeteners cause pre-diabetic symptoms in mice?

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Low-calorie sweeteners (LCSs) are often substituted for sugars. There are concerns about negative health effects stemming from long-term consumption of these compounds. Recent studies have suggested that the consumption of LCSs may cause pre-diabetic symptoms, such as glucose intolerance and weight gain. A previous study in our lab asked whether the supplementation of diet with pure LCS solution could have health defects. However, it did not find any effect on blood glucose tolerance or weight gain in mice. This led us to ask whether consumption of an LCS (saccharin) together with glucose would cause pre-diabetic symptoms, given that diet sodas are often consumed together with carbohydrates. Mice were exposed to one of three solutions (saccharin, glucose, or a binary mixture of glucose + saccharin) for four weeks. Blood glucose tolerance tests were conducted before any solution exposure and at the end of weeks 1, 2, and 4. We predict that exposure to the binary mixture of glucose + saccharin solution will impair glucose tolerance. Unexpectedly, the results so indicate that consumption of the glucose or glucose + saccharin actually improved blood glucose tolerance. The saccharin did not appear to alter glucose tolerance.

55. Mapping dopaminergic neurons co-transmitting glutamate in the VTA utilizing INTRSECT

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Co-transmission of dopamine and glutamate in a subset of neurons in the ventral tegmental area (VTA) of mouse brains has been established, but these neurons have not yet been mapped. Fenno, Lief E., et al. (2014) outlines a new system called INTRSECT, intronic recombinase sites enabling combinatorial targeting, which labels cells with desired features using multiple term Boolean logic. INTRSECT operates on a single adeno-associated virus (AAV) that contains inactive genes for fluorophore expression that are activated if certain recombinase pairings are present in the cells the AAV enters. We utilized INTRSECT to label dopaminergic neurons co-transmitting glutamate within the VTA of tyrosine hydroxylase (TH) FLP and vesicular glutamate transporter 2 (VLGUT2) CRE mouse brains. A bilateral injection into the VTA of the transgenic mice was used to transfect the area with an AAV that causes green fluorescent protein (GFP) expression in the cells that possessed both FLP and CRE recombinases. Immunohistochemistry staining was used to identify fluorophore expression. After analyzing the fluorescence and counting the total number of dopaminergic cells in the VTA along with the number of dopaminergic neurons co-transmitting glutamate in two animals, we found that the dopaminergic neurons co-transmitting glutamate were generally located medially in the VTA and that around 20% of dopaminergic neurons in the VTA co-transmit glutamate. The AAV had a 96% specificity rate, showing that the INTRSECT method was largely successful in labeling only TH/CRE neurons with fluorescence.

56. Social dominance hierarchies are regulated by cortical plasticity in mice

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Neuronal plasticity is enhanced during so-called 'critical periods', or periods of time characterized by an increased sensitivity to stimuli. Many studies have elucidated mechanisms governing critical period plasticity using well characterized models in primary sensory cortex, such as visual cortex; however, modeling critical periods for complex cognitive development remains challenging. Studies in humans and animals demonstrate that the prefrontal cortex (PFC) is important in social cognition. One such phenomenon mediated by synaptic efficacy in the PFC is the establishment of dominance hierarchies. Our lab has previously shown that hierarchies are plastic during adolescence, and in adult mice with juvenile-like cortical plasticity. In these experiments, I explored mechanisms governing social hierarchy plasticity in mice using the tube test, a well-validated assay to test dominance between pairs of mice. Hierarchy formation was assessed in group-housed adult male mice both before and after reactivation of critical period-like cortical plasticity using Valproic Acid (VPA), a drug known to re-open critical periods. Preliminary results show that VPA de-stabilizes dominance hierarchies, providing evidence for a relationship between cortical plasticity and hierarchy stability. Future experiments involve discovering the circuits and cell types involved in hierarchy development and the mechanism by which VPA re-opens the critical period.

57. Uncovering a Pathophysiological Timeline in a Mouse Model of ALS

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Amyotrophic Lateral Sclerosis (ALS) is a neurodegenerative disease affecting upper and lower motor neurons. While the pathophysiology of ALS remains poorly understood, multiple phenotypes thought to underlie pathogenesis have been observed, including abhorrent action potential firing (activity), ubiquitinated protein aggregates, and cellular vacuolization. However, the timeline of pathogenesis in the disease remains unclear. To compare activity in motor neurons vulnerable to ALS to their non-transgenic littermates, we will visualize the axon initial segment (AIS), a structure in the proximal axon that undergoes plastic alterations in response to changes in activity. Here, we asked whether there is correlation between AIS length and the other aforementioned pathological phenotypes. Using the $SOD1^{G93A}$ mouse model of ALS, spinal cord sections were immunostained for p62, marking protein aggregates for degradation; Ankyrin G (AnkG), marking the AIS; and choline acetyltransferase (ChAT), marking all motor neurons. AIS lengths were measured and mutant motor neurons vulnerable to the disease were grouped into three categories based on observed phenotypes: p62 aggregates and vacuolization, p62 aggregates only, and neither p62 aggregates nor vacuolization. Because changes in activity have been shown to cause cell stress, we hypothesized that AIS plasticity would be more severe in those neurons exhibiting the most pathological phenotypes. Preliminary data show that the severity of AIS plasticity does indeed correlate with the severity of the pathologies that arise in motor neurons susceptible to ALS in the spinal cord.

58. Elucidating the mechanism of a TSPO ligand's neuroprotective effect in ALS: The search for organelle-specific colocalization of TSPO

Alice Styczen
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Department of Biology, Barnard College

Amyotrophic Lateral Sclerosis (ALS) is a fatal adult-onset degenerative disorder caused by the deterioration of motor neurons. PK11195 (PK) is a translocator protein (TSPO) ligand with potential to be a treatment for ALS, alleviating motor neuron degeneration in both human and mouse cell models. The goal of this study was to identify whether ALS and PK modify TSPO sub-cellular localization in motor neurons and glial cells through immunocytochemistry imaging. The primary cultures were harvested from embryonic mice, three non-transgenic and three ALS transgenic. Each group was given three different doses of PK: 0 (control), 100 nM, and 250 nM, giving a total of 6 different conditions. Various organelle-specific antibodies were tested for suitability, and three were selected: EEA1, expressed by early endosomes, rab7, expressed by end-stage endosomes, and TOM20, expressed by mitochondria. Each organelle-specific antibody was tested for colocalization with three background antibodies: GFP, expressed in motor neurons, TSPO, the target protein, also expressed in motor neurons, and DAPI, which stained nuclei of both motor neurons and support cells (glia, astrocytes). All of the organelle-specific antibodies were expressed in both motor neurons and support cells. Colocalization of GFP and TSPO was consistent for 17 of the 18 conditions. The exception was TSPO colocalizing with TOM20 in TG PK 100 conditions, where it was expressed within mitochondria, and not in the overall motor neuron. This preliminary finding suggests that PK can cause TSPO to migrate. Further testing is required, but all three organelles are yet potential cellular targets of PK.

59. Relative Learning in the Duration Discrimination Task

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Time is a crucial dimension of behavior. The ability to process time over a range of intervals, from milliseconds to days, is implicated in a wide range of processes: sleep-wake cycles, appetite, speech, and motor control. Interval timing, which occurs in the seconds to minutes range, allows animals to make adaptive decisions and form anticipatory behaviors based on temporal contingencies present in the environment. It is therefore important to understand how temporal information is encoded and processed. To that end, we employed a reversal learning paradigm in which mice were first trained to respond differentially to long and short durations. Then, in order to investigate if these contingencies are encoded in an absolute (e.g, 6 seconds) or relative (e.g, long duration) representation, the response and/or duration of cues were switched so that either the relative or absolute mapping remained constant. Temporal discrimination performance was analyzed with respect to accuracy and response times associated with short and long choices. It was found that the new contingencies were easier to learn when the relative temporal mapping between the times and responses remained constant. We can therefore conclude that, while animals do process the absolute relation between durations, they rely more heavily on the relative representations of time to guide their behavior.

60. Sex differences of hippocampal gene expression in mice

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Neurogenesis, the growth and development of new neurons, is a key component of hippocampal function and has potential for repairing brain damage, even in adulthood. Furthermore, neurogenesis dysregulation is correlated with neuropsychiatric and developmental disorders that affect the sexes differently. Past research using immunocytochemistry suggests that there are sex differences in neurogenesis in rats, but not in mice. However, our mouse microarray data in the dentate gyrus (DG) suggests that there are genes that are upregulated in males and downregulated in females, and vice versa. We hypothesize that there are sex differences in gene expression in mice, and that these were missed in prior studies due to low detection levels. The goal of this study is to revisit the question of possible phenotype-specific sex differences in the neurogenesis of mice using in situ hybridization (ISH). To explore whether sex differences exist in adult mice neurogenesis, we performed ISH to visualize gene expression in the hippocampus, comparing expression of 11 male upregulated genes associated with cell survival and 11 female upregulated genes associated with cell proliferation in both male and female brains. Early growth response 1 (Egr1) and possibly POU domain, class 3, transcription factor 1 (Pou3f1) are more highly expressed in the hippocampus of males than females. There were no noticeable difference between sexes in 9 additional genes studied. These findings suggest that there are sex differences in gene expression in the hippocampus of mice. The next step will be to determine whether differences are due to sex differences in circulating hormones or to genetic differences in the sexes.

61. Developing Tools to Visualize Sex Differences in the Brain

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Sex differences affect many facets of biological function and dysfunction. For example, some disorders in humans, such as Alzheimer's disease, anxiety, and depression, have different incidences in males and females. One brain region implicated in these disorders is the hippocampus, which shows neurogenesis in adulthood and is important for memory and emotionality. Prior gene array results indicated that adult male mice display higher levels of genes related to cell survival in the hippocampus compared to females. For instance, the transcription factor *Egr-1* gene was significantly higher in males than females, but the localization and cell type specificity within the hippocampus is unknown. The present study seeks to establish a method to validate and extend the previous gene analysis results. Specifically, we are using the thymidine analogue, BrdU, to label recently born cells while co-labeling for EGR-1 protein in the male and female hippocampus. Though experiments are still in progress, we have validated BrdU and EGR-1 antibodies and thus have established their single label specificity. Currently, we are troubleshooting a double labeling protocol so that we can visualize both antibodies in the same tissue section. Ultimately, these tools will allow us to quantify potential sex differences in hippocampal neurogenesis. This could help elucidate the mechanisms that contribute to disorders that show different incidences between the sexes.

62. Effects of Acute Selective Serotonin Reuptake Inhibitor Administration on Fear Memory Reconsolidation

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Selective serotonin reuptake inhibitors (SSRIs) are often prescribed to treat anxiety disorders and depression. Continued treatment for several weeks lowers anxiety though acute SSRI administration paradoxically increases anxiety. Past research has demonstrated that acute SSRI administration *before* fear conditioning in male rats enhances fear learning and memory formation. However, in human patients, SSRI treatment usually begins *after* fear learning or a traumatic event occurs. Thus here we explore the effects of acute SSRI administration on the reconsolidation of a fear memory. Reconsolidation of a memory occurs when a reminder cue brings the original fear memory into a labile state. The memory can then be altered before it is reconsolidated. Our previous research indicates that SSRIs have no effect on reconsolidation of fear memories in male rats. However, SSRIs have been shown to affect the BNST, which is a sexually dimorphic brain structure recruited during fear learning and anxiety-like behaviors. In order to observe the effects of SSRIs on fear reconsolidation in female rats, animals were trained using a standard Pavlovian fear conditioning protocol in which tone conditioned stimuli (CSs) were paired with aversive footshocks. 24 hrs later, they were given the SSRI citalopram (10mg/kg, i.p.) or saline immediately after one tone recall. Memory was assessed drug free 24 hours later with 10 tones. Our preliminary data suggest that acute SSRIs enhance fear reconsolidation in female rats.

63. The Role of vasoactive-intestinal peptide (VIP) interneurons in working memory

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Various psychiatric disorders have been associated with working memory impairment, including ADHD, schizophrenia and bipolar disorder. This impairment has been hypothesized to be a result of failed functional connectivity in the brain, but the cellular connectors and their roles in the working memory circuit are not well understood. Previous data has demonstrated that vasoactive-intestinal peptide- (VIP) interneurons exhibit abnormal expression of VIP, GABA synthetic enzyme and GABA transporter in individuals with schizophrenia. We hypothesized that VIP interneurons participate in the working memory circuit by improving functional connectivity and, when those interneurons are not functioning normally, working memory is impaired. To test this hypothesis, we used the light-activated proton pump Arch3.0 to selectively silence prefrontal VIP interneurons in the medial prefrontal cortex of mice while performing the delayed non-match to sample T-maze test of spatial working memory. The T-maze tests working memory encoding (sample phase), maintenance (delay phase) and retrieval (choice phase). We simultaneously recorded neural activity in the medial prefrontal cortex (mPFC) and other brain areas known to be involved in working memory, including the dorsal and ventral hippocampus (dHPC and vHPC), and mediodorsal thalamus (MD). We used measures of LFP-LFP and spike-LFP synchrony to characterize the functional connectivity between the mPFC and these other brain areas. Silencing VIP interneurons during the choice phase of the task improved working memory performance when the delay length was 10 seconds or 60 seconds.

64. Can mice be conditioned to release insulin in response to the taste of artificial sweeteners?

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During and after a meal, animals experience a rise in blood sugar associated with the nutrients they have consumed. To counteract this elevation in blood sugar, animals release the hormone insulin. Insulin release can be elicited by at least two mechanisms. It can be released directly from beta cells in the pancreas in response to elevations in blood sugar. Second, even before ingestion begins, the taste, smell, or visual input provided by food can activate a neural pathway that elicits insulin release. We are focusing on this latter mechanism, which is called cephalic phase insulin release (CPIR). Prior studies in our lab have demonstrated that CPIR is elicited in mice in response to oral stimulation with glucose but not artificial sweeteners. Importantly, these mice lacked any prior exposure to artificial sweeteners. We asked whether B6 mice can be conditioned to generate a CPIR in response to oral stimulation with an artificial sweetener called saccharin. We will obtain mice with surgically implanted intragastric catheters and repeatedly pair intragastric infusions of glucose with oral stimulation by saccharin. We hypothesize that these repeated pairings will cause the mice to trigger CPIR in response to saccharin. Experimentation is currently under way.

65. *Cellular Characterization of an Extended Amygdala Circuit*

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The amygdala is a structure in the brain associated with several behaviors including fear learning and memory formation. In this experiment, we focused on characterizing the connections between the bed nucleus of the stria terminalis (BNST), a region of the extended amygdala, and the central nucleus of the amygdala (CE). These reciprocally connected structures are involved in learning and expression of fear and anxiety-like behaviors. They share similar cell types and efferent targets, suggesting that they might coordinate their activity and/or function in parallel. Within the CE, two subpopulations of neurons gate the expression of fear behavior and can be identified by the specific neuropeptides and kinases they express. However, the BNST neurons in this pathway are not as well understood. We have previously shown that the BNST-CE pathway is active during the expression of contextual fear conditioning. Thus, the goal of this project was to characterize the cells in the BNST in terms of the neuropeptides they express, specifically neuropeptide Y (NPY) and corticotropin releasing factor (CRF). In the BNST, NPY is associated with a reduction in anxiety and stress, while CRF has the opposite effect of increasing anxious behaviors. We first labeled neurons in the BNST which project to the CE by infusing the retrograde tracer FluoroGold (FG) into the CE of male and female rats. Standard immunohistochemical techniques were used to determine whether FG+ neurons in the BNST express the neuropeptides NPY or CRF. By characterizing the neurons in the BNST-CE pathway we can better understand the cellular basis of fear learning.

66. SRGAP2 Deficiency Leads to Reduced Neuronal Activation in the Dorsal Dentate Gyrus in Novel Environment Behavior Experiment

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Compared with all other primates, human neocortical neurons have a strikingly high synaptic density which is thought to underlie our cognitive abilities. However, the mechanisms regulating synaptic density are not well understood. The Polleux lab has identified a gene, Slit-Robo Rho GTPase activating protein 2 (SRGAP2), that controls the maturation and density of synaptic connections. The ancestral copy of this gene, SRGAP2A, is present in all vertebrates. The gene underwent a duplication event only in humans resulting in a human-specific copy, SRGAP2C, that also influences synaptic density. However, nothing is known about the functional consequences of manipulating the gene. Here, we test whether SRGAP2 has a functional role in exploratory behavior. SRGAP2A knockout mice were exposed to a novel environment and the immediate early gene product, c-fos, was used as a marker for recent neuronal activity. We quantified the number of neurons in the dentate gyrus, a region of the hippocampus known to play a crucial role in processing spatial information. Preliminary findings showed a trend in which SRGAP2A knockout mice have a reduced number of c-fos positive cells in the dorsal hippocampus. These results suggest two possible implications: 1) the human brain is more efficient at encoding sensory information and so requires fewer cells for processing, or 2) SRGAP2 deficiency actually hinders circuit function and requires additional mechanisms for information processing. Future experiments will attempt to distinguish between these hypotheses and test expression of SRGAP2C in this paradigm.

67. Polyunsaturated fatty acids are not associated with cortisol levels in response to serotonergic challenge in major depressive disorder

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Serotonergic dysfunction is implicated in the etiology of major depressive disorder (MDD). Serotonergic activity is influenced by omega-3 and omega-6 polyunsaturated fatty acids (PUFAs) in animal studies. However, information about PUFAs and serotonergic function in humans remains scant. The serotonergic system exhibits a complex, multiphasic relationship with cortisol in healthy individuals that is altered in patients with MDD. Therefore we studied relationships between PUFA levels and cortisol responses to challenges with the serotonin (5-HT) probe *d,l*-fenfluramine (FEN), a serotonergic marker. We assessed baseline plasma phospholipid levels of omega-3 PUFAs docosahexaenoic acid and eicosapentaenoic acid, and the omega-6 PUFA arachidonic acid, as well as plasma cortisol levels before and after FEN and placebo administration in 23 medication-free adults with DSM-IV MDD. In a linear regression model, 17-item Hamilton Depression Rating Scale score (HAM-17) and PUFA measures were independent variables with total cortisol output (area under the curve) or peak cortisol change from baseline as dependent variables. Age and sex were tested separately as covariates. Both indices of cortisol response to FEN were positively correlated with the HAM-17 score. No correlations were observed between PUFA measures and intensity of the cortisol response to FEN. The lack of relationships between PUFAs and serotonergic indices suggests that PUFAs may not influence depression pathophysiology through effects on the serotonergic system. This is consistent with previous findings that PUFA effects may be more prominent in dopaminergic systems.

68. DGRP Screen for Amphetamine Induced Behaviors

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The Drosophila Genetic Reference Panel (DGRP) is a collection of over 200 lines of *Drosophila melanogaster*, bred to near homozygosity. Although all of the lines are fully sequenced, little data has been collected about the behaviors of these lines. Previous work has been done by this lab to identify the genetic basis for hypersensitivity to 5 mM of amphetamines in a specific strain of *Drosophila* not included in the Panel. We decided to perform a screen of a number of lines from this collection to assess behavioral differences in relation to the effects of amphetamine at 0 and 10 mM concentrations. The activity of five, one-week old flies from each line were tested at each concentration in a light-dark 12-hour cycle and consistently dark conditions for a week long period. Previous research exists on the differences in circadian rhythms between lines. The resulting data showed large variability in responses to all tested concentrations of amphetamine between inbred lines, with low levels of uncertainty within each condition for each line. There was also high levels of variability in regards to mortality and effects on circadian rhythm between the lines, both in entrained and un-entrained conditions. This data may be used in the future to select lines for further, more specific testing.

69. Tau Pathology Immediately Impairs Memory and Long Term Potentiation

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Forms of extracellular oligomeric Tau (oTau) are known to play some major role in Alzheimer's Disease (AD). We hypothesized that tau pathology, initiated by oligomeric Amyloid beta, spreads throughout the cortex, leading to memory loss. It was determined that exposure to oligomeric tau leads to impairment of memory and long-term potentiation (LTP). Mice were injected with oTau directly into each hippocampus through cannulation. These mice then went through a set of behavioral testing, each mouse being tested 20 minutes after being injected with 180 microliters twice, in order to determine the affect of Tau on their normal behaviors and memory. Following Radial Arm Water Maze (RAWM), the mice injected with oTau made more mistakes than control mice. Slices of mice hippocampi went through a study of LTP, in which the strength of electrical responses to stimuli was measured to determine which synapses had undergone LTP. The hippocampi of mice injected with oTau had undergone less LTP. We conclude that oligomeric Tau contributes to memory loss and decreases in LTP in AD. These findings suggest a possibility for treatment in which the formation and spreading of tau throughout the brain would be blocked.

70. Effects of acute stress on reward prediction activity in VTA-NAc neurons

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Mentors: Alexander Harris
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Dopamine neurons in the VTA fire phasically in response to an unexpected reward. As the reward becomes associated with a cue, these neurons firing to the presentation of the cue rather than the reward. An unexpectedly small or large reward results in either a dip or an increase in dopaminergic firing, respectively. Recently, the Uchida group demonstrated that a precise interplay between VTA GABA and dopamine neurons underlies this phenomenon (known as reward prediction error). Both VTA dopamine and GABA neurons also respond to stressful experiences. We are recording VTA single unit activity as we train awake, freely moving mice in a reward prediction error task. We hope to determine the effects of restraint stress, a negative experience, on both the behavior and VTA neural activity during reward prediction error. We will use conditioning to establish cue/reward associations followed by experiments in which both unexpected and expected rewards are presented. We will compare the responses in these experiments before and after experiencing acute restraint stress.

71. Analysis of a whole-neuron synaptic reconstruction reveals structure at domain and branch levels

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The function of neuronal circuits is controlled by extremely precise connectivity among specific neuronal cell-types. Synaptic plasticity and clustered stabilization have been shown to contribute to structured synaptic development; however, little is known about connectivity at the level of dendritic domains and individual branch segments. Here, we examined synaptic development by creating a 3D reconstruction of a L2/3 somatosensory pyramidal neuron. We reconstructed the neuron using synapse detection software developed in collaboration with the Allen Institute of Brain Science to identify excitatory and inhibitory synapses. We show that the distribution of both types of synapses is structured by domain and branch type. Among dendritic domains, there is an inverse relationship between spine and inhibitory synaptic density; however, there is a positive correlation between spine density and inhibitory synaptic density across all terminal segments regardless of domain. Additionally, there is a high proportion of dually innervated synapses found on terminal tufts, where L2/3 pyramidal neurons receive thalamic input. Our results demonstrate that pyramidal neuron connectivity is much more precise on the branch level than previously appreciated, and may impact dendritic integration and neuronal circuit function.

72. The Development of the Human Memory Model: How attachment and familiarity affect memory encoding

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The human brain is responsible for storing and aiding in the retrieval of all information that one encounters throughout their lifespan. How the storing and retrieval takes place, however, has been the topic of many research studies throughout the Cognitive Neuroscience field. A particular topic of interest is the way in which the memory model develops, namely, what features are most strongly encoded, and which brain regions are utilized to transform an initial encounter with a person into a fully formed model? To date, many research studies have focused on the importance of familiarity and attachment on the memory encoding process. Results have shown that stimuli that are more relevant or personal to the subject, are encoded separately, and oftentimes more strongly, than those that are meaningless or irrelevant. These meaningful associations or attachments are stored in the hippocampus and the vmPFC (ventromedial prefrontal cortex), and exist separately from brain regions such as the anterior temporal lobe, which stores memories that are more semantic and impersonal by nature. To date, a developmental model, that accounts for the developing changes in attachment that occur as a child matures from infant to adult, has not been thoroughly proposed. An experimental design is currently underway.

73. Autism Spectrum Disorder in the Mouse Model: The Behavioral and Biological Analysis of G56A Mice

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Hyperserontonemia, or elevated serotonin (5-hydroxytryptamine, 5-HT) in the blood, was the first biomarker attributed to autism spectrum disorder (ASD), which also identified the serotonin transporter (SERT) as a point of interest in ASD research. Using a knock-in mouse model of the SERT variant Gly56Ala (G56A), which carries a genetic alteration seen in many ASD diagnoses, we sought to characterize mutant phenotypes through basic behavioral tests. The elevated zero maze tests anxiety-like behaviors by measuring the percent of time that a mouse spends in a closed arm of a maze rather than in an open arm. The open field test measures activity by recording the distance traveled by a mouse within a open field. For both tests, we hypothesized that the G56A mice would show more ASD-like behaviors than their wild type counterparts — increased time in a closed arm and less distance traveled, respectively — yet we did not find any results to be statistically significant. We then used immunohistochemistry to check where serotonin might be originating from and projecting to in the G56A mice. Starting in the dorsal raphe, also known as the serotonergic nucleus, we found serotonin. Next, we considered the prefrontal cortex and hypothalamus as places for possible 5-HT projection, both of which have implications in behaviors relevant to ASD. We look forward to continuing our investigation of these areas in hopes of further understanding ASD and developing novel treatments for the disorder.

74. Ethanol consumption by adolescent rats is modulated by palatability, prior experience and post-ingestive effects

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Ethanol is a potent drug that humans have been consuming for thousands of years. Despite our long history of alcohol use, we still do not understand the factors that regulate consumption. We are developing an adolescent rat model system to study this problem. For this study, we focused on three factors thought to modulate ethanol consumption: palatability, prior experience and post-ingestive effects. To study palatability, we mixed a sweetener cocktail with the alcohol. To study prior experience, we subjected rats to 8 days of intermittent exposure to 10% ethanol. To study post-ingestive effect, we used short-term lick tests to minimize any potential post-ingestive effects of the ethanol. We found that alcohol consumption increased with the addition of the sweetener cocktail, indicating that palatability matters. We also found that experience with alcohol produced complex effects, increased consumption is some and decreasing it in others. Finally, we found that when post-ingestive effects of ethanol were minimized, rats increased their intake of dilute ethanol solutions.

75. Proteoglycan-Deficient Retinas Demonstrate a Retinal Degeneration Phenotype

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Retinitis pigmentosa and *Leber's congenital amaurosis* are congenital genetic disorders that directly affect millions of lives worldwide. Caused by photoreceptor cell death, the two maladies lead to progressive vision loss, beginning from early childhood into adulthood. Mutations in the Crb1 gene have been found in these disorders. In recent studies, the Crb1 protein has been linked to polarity of photoreceptor cells, specifically. Patients carrying the Crb1 mutation demonstrate the formation of rosettes in the photoreceptor cell layer, as a result of changes in cell polarity. However, the underlying mechanism remains unknown. In our lab, this Crb1 phenotype is found in retinas lacking proteoglycans. Proteoglycans are heavily glycosylated proteins that affect numerous cell signaling and development processes. Proteoglycans contain side chains, specifically heparan sulfates and/or chondroitin sulfates, each with varying functions. Recent protein binding experiments demonstrated that heparan sulfate proteoglycans bind laminins. The suggested binding sites for proteoglycans on laminins, known as laminin A/G domains, are also found on the Crb1 protein. Based on these findings, we hypothesize that heparan sulfate proteoglycans bind to the laminin A/G domains of the Crb1 protein and thereby contribute to the polarity of photoreceptors. For this purpose, we use a mouse model which lacks the expression of heparan sulfate proteoglycans in the peripheral region of the retina. We study and characterize this mouse model by staining for retina specific markers to assess whether the absence of proteoglycans affects only photoreceptors or also other retinal cells.

76. Immunohistochemical analysis of tau protein using transgenic mice

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Tau is a predominantly intracellular protein that becomes highly phosphorylated and aggregated into abnormal filaments in Alzheimer's Disease (AD). While the mechanism underlying of tau's pathological actions is unknown, studies have shown that tau (1) stabilizes microtubules in presynaptic cells, (2) has signaling function in postsynaptic cells, and (3) is found in extracellular space. The overall purpose of my research was to examine the mechanism of tau and how tau contributes to AD. To do this, I developed AAV vectors that contain mutant human tau-GFP transgene flanked by loxP recognition sites. Stereotaxic injection of tau expressing AAV and gfp expressing control vectors was performed into the brains of transgenic mice. To restrict the expression mutant tau, two lines of transgenic mice that had regionally restricted expression of CRE recombinase were used. When AAV vectors are injected into these lines, tau is expressed only in CRE-expressing cells on either the presynaptic or postsynaptic side of the Schaffer collateral synapse. The AAV-tau transgenes were analyzed at 2 and 4 weeks after injection with immunohistochemistry. Antibodies against tau5, CP13 and gfp were used. Our preliminary data have confirmed tau expression in the Dentate Gyrus and CA3 region in 2 and 4 weeks. We will further examine the role of tau in AD by electrophysiological analysis of these mice - specifically tests of long-term potentiation (LTP), long-term depression (LTD), and paired pulse facilitation (PPF) previously found to be impaired in other mutant tau models without pre- and postsynaptically restricted expression.

77. Dopamine and Glutamate Co-Transmission in Patch and Matrix Components of the Mouse Striatum

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Dopamine (DA) is a neurotransmitter that controls the brain's reward and pleasure centers, regulates movement and emotional responses, and plays a major role in addiction as well as in diseases such as Parkinson's and schizophrenia. Recent research has found that in certain areas of the striatum, dopamine is co-transmitted with another neurotransmitter, glutamate. This research focused on dopamine and glutamate co-transmission in two components of the striatum, the patch and the matrix, which have distinct projection targets, inputs-outputs, and neurochemical markers. To stain and visualize the patch/matrix distinction in this experiment, we used a marker called the mu-opioid receptor, which is found in the patch. We specifically looked at dopamine and glutamate co-transmission in the patch and matrix; by utilizing electrophysiological recordings and post-recording immunohistochemical staining, we attempted to visualize whether this co-transmission was preferential in patch or matrix and whether or not it was through a direct (D1) or indirect (D2) dopamine pathway. Additionally, glutamate is important for the development of meso-striatal dopamine projection, and because the patch develops earlier than the matrix, we hypothesized that by knocking out glutamate, the patch-matrix structure would change. We used VGLUT2 conditional knockout (KO) mice and compared their patch -matrix structures to that of wild type (WT) mice. We do not have definitive results yet as we are still perfecting the immunohistochemical staining method. Although this research is still in its initial stages, understanding more about dopamine and glutamate signaling is important to furthering our understanding of many neurological diseases and processes.

78. Testing the efficacy of biofilm-resistant urinary catheters

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Catheter-associated urinary tract infections (CAUTI) cause 8000 deaths per year. In order to meet the demand for biofilm-resistant urinary catheters, the Modak lab has engineered two types of antimicrobial silver sulfadiazine catheter coatings: FDP-AgSD, which is comprised of two polyurethandes and several salts, and FTP-AgSD, which is comprised of the components of the FDP-AgSD group and one additional polymer. Variations of the two coatings were created and tested in the lab to determine which coatings best inhibited biofilm growth. We hypothesized that the FTP catheters would resist bacterial growth longer than the FDP catheters. 2 cm pieces of coated catheters were placed in 2 mL infected urine, incubated at 37°C for 24 hours, and kept on an incubated shaker for 30 minutes in saline solution. The catheters were then rolled on drug neutralizing media (D/E agar) to determine the bacterial adherence to each catheter, and the urine was subcultured to determine the extent to which the catheter coating released its antimicrobials and inhibited bacterial growth in its surrounding environment. The catheters were then placed into new infected urine and the tests were repeated daily until bacterial growth was no longer inhibited. An uncoated catheter was used as the control. Zone of inhibition tests also demonstrated the length of time that each catheter coating was able to inhibit bacterial growth in its environment. We found that the FTP catheters inhibited biofilm and surrounding bacterial growth for a greater number of days than the FDP catheters.

79. Chronic Early Life Stress Induces Greater Susceptibility to Social Defeat

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Early life stress has long lasting effects on the developing brain including the medial prefrontal cortex - a brain region strongly implicated in mood disorders such as anxiety and depression (Chocyk et al., 2013). How these early life adversities interact with genetic factors and later life stress to promote susceptibility or resilience to such psychopathologies is unclear. Daskalakisk proposed a three hit model of vulnerability to stress-related mood disorders (hit 1- genetic predisposition, hit 2 - early life stress (ELS), hit 3- adult life stress) and reported that rats who underwent ELS demonstrated various behavioral deficits later in life (Daskalakisk et al., 2013). In this experiment, we studied the effects of early life stress on sensitivity to future stress and subsequent development of depressive and anxiety-like behaviors in mice. We used an established chronic ELS model for rodents (Molet et al. 2014) and a social defeat (SD) paradigm recently refined to include female subjects (Harris et al. 2017) to develop a two-hit model of chronic stress. We hypothesized that subjects who underwent limited nesting and fragmented maternal care during the early life stage will be more susceptible to social defeat stress and display higher levels of anxiety- and depressive-like behaviors than subjects who undergo normal maternal care. We found that social defeat significantly lowered sucrose preference, an indicator of anhedonia, in ELS subjects than in controls, as well as a decrease in social interaction and increase in avoidant behavior in male ELS subjects.

80. Probing Neural Mechanisms Mediating Pubertal-and-Sex-Related Changes in Metabolism

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Puberty is marked by significant changes in metabolic function, which can be further modified by the sex of the individual. Unfortunately, puberty is also a time in development associated with many physiological dysfunctions, such as the onset of obesity and the metabolic syndrome. Currently, the factors that mediate the increase in these dysfunctions still remain unclear. In an effort to better understand neural mechanisms that contribute to pubertal-related changes in metabolism, our study investigated hypothalamic neuropeptides important in metabolism and feeding, including proopiomelanocortin (POMC), Orexin-A, and Neuropeptide Y (NPY). Specifically, we examined the arcuate nucleus and the lateral hypothalamus in C57BL/6n pre-pubertal (30d) and adult (70d) male and female mice. While POMC and NPY are involved in suppressing and stimulating appetite respectively, Orexin-A is involved in arousal and activity. Given the dramatic increase in somatic growth and energetic demands during puberty, we predict greater NPY and Orexin-A levels with lower POMC levels in the hypothalamus in pre-pubertal compared to animals. Moreover, given the sex difference in body size and weight gain, we predict the changes in these neuropeptides will be greater in males than females. Though experiments are still in progress, we have collected all the brain tissue and have validated all of the antibodies used to identify these neuropeptides. These experiments will ultimately contribute to a deeper understanding of how puberty and sex influence metabolic function and provide a foundation to further study metabolic dysfunctions during adolescence.

81. Combined Neurological effects of Methamphetamine and HIV/ AIDS

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Rationale: Methamphetamine (Meth) abuse is often associated with individuals infected with HIV (human immunodeficiency virus). Meth is a highly addictive psycho stimulant that can alter the function of immune cells and increase brain viral load, which is correlated with an increase of CCR5-expressing cells (cells that function as receptors for HIV entry into host cells). HIV, which is aggravated by Meth, can cause many different neurological conditions such as dementia, neuropathy, and lymphomas. To increase our understanding of the combined effects of HIV and Meth on the brain, an animal model is required to study neural mechanisms involved in Meth abuse and HIV/AIDS interactions. Objective: To understand mechanisms of Meth action in the brain, we aim to study mice that mimic the immune state of HIV/AIDS patients. Specifically, CCR5 Knockout (KO) mice (mice that lack the CCR5 protein) will be used. Methods: Male and Female CCR5 (both KO and littermate control) mice were kept in their cages and given 1 h (2-3pm) daily access to a tunnel that leads to a chamber that has nebulized Meth. When the mice voluntarily enter the chamber, they inhale the Meth. The time spent in the chambers and their activity (based on wheel running) is then recorded and analyzed. In a subsequent study, mice will be given a fixed amount of Meth through injection. At the end of this study, the brains of these mice will be examined and breech of the BBB, microglial activation, and protein extravagation will be studied. Results and Conclusion: Behavioral testing of voluntary intake of Meth showed that there is no significant difference between the amount of time CCR5 KO and CCR5 littermate control mice spent in the chamber. Further studies will be done to examine the physiological effects of Meth and HIV on the brain.

82. Effects of Intrinsic Temporal Distortion on the Multimodal Perceptual Organization of Speech

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Mentor: Samantha I. Caballero, Andrea A. Willimetz, Robert E. Remez

Why look at the talker when you listen? According to recent research, multimodal speech perception may be more tolerant of temporal distortion than unimodal auditory perception. We tested this conjecture by attempting to disrupt perceptual organization in order to deduce the integration of auditory and visual sensory samples. Subjects with normal vision and hearing listened to sine-wave speech samples while watching video recordings of a talking face. In the first condition, the auditory sensory samples underwent intrinsic temporal distortions of 30 ms, 60 ms, or 90 ms. In the second condition, the visual sensory samples underwent intrinsic temporal distortions of 30 ms, 60 ms, or 90 ms. In the third condition, the auditory and visual sensory samples remained unperturbed temporally. Intelligibility of unperturbed speech was 45.2%. Any type of auditory distortion rendered its contribution to multimodal integration useless or nearly so. However, distortion of the visual component was tolerable at 30 ms. At 60 ms and 90 ms of distortion, the visual component still contributed to integration. These measures expose the differential and characteristic temporal dynamic of each sensory modality in audiovisual integration.

83. Do smartphone applications help with migraine treatment? Using the RELAXaHEAD app to track migraines and deliver behavioral treatment

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Migraine is one of the most common chronic conditions that affects 12% of the US population. Patients presenting to the Emergency Department and the outpatient setting often find that the care with which they are provided is not effective in the long-term treatment of their migraines. In this study, we seek to determine whether behavioral treatments delivered via a smartphone app would be effective in reducing the pain associated with migraine headaches as well as improve patients' symptoms of depression and anxiety. This study has two branches: patients presenting to outpatient centers being treated for migraine; and, patients presenting to the Emergency Department presenting with migraine. Eligible patients are approached and complete an in-person survey discussing their history with migraines. They are then asked to download the app and complete a Progressive Muscle Relaxation therapy session in person. Patients are asked to to input their headache data into the app every day and to complete 20min of PMR therapy every day for three months. It was hypothesized that patients given the PMR therapy would see a decrease in their headache days after 3 months. In addition, we seek to assess the quality of other smartphone apps that claim to help patients with their migraines. Twenty of the top-rated migraine apps were analyzed to determine their credibility and utility in treating migraines as well as the patient and doctor expectations relating to the use of smartphone apps. As data is still being collected, there are little preliminary findings of this study.

84. Counting Behavior in Mice

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The human capacity for mathematical thought is critical to many decisions and societal functions, and this ability has been shown to mature during human development from its beginnings in infancy. In efforts to understand the neural basis of numerical cognition, comparative studies have shown that a number of species, including non-human primates, fish, birds, and rats, have approximate number systems and the ability to distinguish different quantities of objects. However, in order to directly probe the function of neurons putatively involved in representing numeracy, it would be useful to demonstrate the existence of this ability in a tractable model system. It remains unknown whether mice, an animal model that provides genetic and neural accessibility, can count.

We are therefore designing a behavioral paradigm to ask whether mice can count.
We will deliver neutral odors to head-fixed mice and ask by monitoring anticipatory licking whether they can associate the *n*th presentation of odor with water reward. We will vary the timing of both odor presentations and inter-odor intervals to ensure that mice judge the number of stimuli, rather than elapsed time. We will also probe for the effects of distinguishing different quantities (4 vs 5 vs 6 compared to 2 vs 10), as non-human numerical abilities have been shown to be approximate. The demonstration of a behavioral neural capacity for numerosity in mice via odor could eventually allow us to directly probe the function of olfactory system neurons in representing quantity.

85. Alternations in astrocyte cell cycle regulation at the G_1/S phase checkpoint: Molecular and pathological perspectives in the context of Alexander Disease

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Though astrocytes have traditionally been labeled merely "support cells of the CNS," their full range of function has yet to be uncovered. Particularly, the cellular mechanisms of astrocyte cell proliferation—and its start and end signals—is still relatively unknown. At the onset of various neurological conditions, including neurodegenerative diseases, CNS inflammation, brain trauma, and stroke, astrocytes will proliferate for about one or two additional cycles but then abruptly stop. However, in the case of pilocytic astrocytoma (a brain tumor originating from astrocytes), astrocytes continue proliferating without end. Alexander Disease (AxD)—disproportionately affecting children—is a rare neurodegenerative disease caused by mutations in the *GFAP* gene, which encodes the major intermediate filament protein of astrocytes. AxD pathology includes overaccumulation of GFAP and Rosenthal fibers (protein accumulations of GFAP, heat shock proteins, and other components), myelin sheath degradation, and significant impairment to motor skills and normal development. AxD shares some common characteristics with pilocytic astrocytomas, namely the presence of Rosenthal fibers, yet AxD exhibits regulation of astrocyte cell cycle proliferation, whereas pilocytic astrocytomas grow slowly but inexorably. We are investigating various genes proposed to be involved in astrocyte cell cycle regulation from G_1 to S phase, including CDK1, CDK2, CDK6/4, p27, TRP53, p21, CDKN2b, p38, c-myc, cyclin D1, and cyclin D2. The transcript levels of most of these genes are significantly elevated in AxD, suggesting the presence of both pro-proliferative and anti-proliferative signaling. Western blot confirmed that the level of cyclin D2 protein is significantly increased in AxD model mice. Interestingly, the cyclin D2 protein is associated with Rosenthal fibers in AxD. Our immunostains also reveal this association in pilocytic astrocytomas. Experiments in the near future will assess, in AxD mice, protein levels of the above genes to validate their up- and downregulation. Immunostainings of tissues will determine where these proteins are localized to help give insight into their functional mechanism. We will also investigate these genes and protein levels in pilocytic astrocytomas. In the future, we will perform assays in rat astrocyte cultures, where cells first proliferate and then stop, to see which genes are involved in this transition.

86. Ticking of the Brain Clock: Knockout of a major timekeeper (VIP) changes network composition but not connectivity

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Most physiological processes are maintained over a 24 hour cycle called the circadian rhythm. This rhythm is regulated by the biological clock known as the suprachiasmatic nucleus (SCN) which acts through a network of peptidergically heterogeneous neurons. While these peptidergic cell types have been identified, little is known about the connectivity of this network. Our project aimed to elucidate the SCN's neural circuitry by comparing the peptidergic network of wild type mice to that of VIP-knockout (VIP-KO) mice, which lack the VIP peptide and are known to be arrhythmic. We studied the topography of the SCN in VIP-KO mice and examined changes in the number of, and connections between, peptidergic cell types. We compared the intercellular SCN circuitry in Wild-Type (WT) to VIP-KO mice using immunocytochemistry to reveal AVP, CalR, GRP and ENK neurons and connections between them. Compared to WT, VIP-KO mice have the same number of CalR, GRP and ENK cells but fewer AVP cells in the SCN. In contrast, there was no difference in the number of AVP cells outside the SCN - in the PVN or the SON. Finally, there was no difference in number of connections between AVP, CalR, GRP and ENK cells. In the absence of VIP, AVP expression is reduced specifically in the SCN. In the VIP-KO, there were no alterations in the number of, or connections between, other peptidergic cell types. Studying the network organization of the SCN is key to understanding the consequences of genetic mutations in specific molecular components of the brain's circadian clock.

87. Understanding the Relationship between Subjective Social Status, Hair Cortisol, and Mental Health in Parents and Children

Pooja M. Desai
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Poverty is one of the most pressing issues currently affecting children in the United States, with 21% of children living in homes below the federal poverty line. Research over the past several decades has established a link between poverty and poor health outcomes, with a growing body of literature demonstrating the significant effects of poverty on children's brain development and stress physiology. Measures of socioeconomic status (SES) include objective indices, such as family income and parental education, and subjective social status (SSS), defined as an individual's "perceived location within the socio-economic structure". While considerable past research has focused on objective measures of SES, less is known about the role of SSS in predicting children's developmental outcomes. This study aims to address this gap in the literature by examining associations among SSS, physiological and perceived stress, and mental health in 5- to 9-year-old children and their parents. Participants of varying economic backgrounds ($N = 72$) were recruited from local New York City neighborhoods to participate in this study. Parents reported on SSS and parent and child mental health, and hair samples were collected from parents and children to measure hair cortisol, which is a physiological measure of chronic stress. Findings will make important contributions to what is known about how poverty may "get under the skin" to influence health outcomes across the lifespan.

88. The Effect of Amphetamines on Counting-Based Decisions

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Goal directed motivation involves efficiently selecting behavior that leads to a specific goal. Previously, it has been shown that amphetamine increases responding in tasks that measure goal-directed action. We wondered whether the hyper responding produced by amphetamine was processed as a goal-directed action by the animal. This study aims to determine whether subjects given amphetamines are aware of such hyperactive motor output using a counting-based task. It has been demonstrated that rodents are capable of counting their responses to maximize reward rates in count-based decision making (Mechner, F., 1958). Using a fixed consecutive number schedule, subjects were simultaneously presented with a left lever for counting and right lever that would produce a reward if the proper number of responses had been made on the left lever. If subjects press the left lever less than the minimum number of times and then press the right lever, the trial resets without reward. Once amphetamines are administered, each subject's ability to keep count of its hyperactive motor output will be determined by the number of presses on the left lever before switching to the right.

89. Prenatal Alcohol Exposure Decreases EEG Power of Preterm Infants

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Exposure to alcohol or tobacco interferes in fetal development, causing long-lasting cognitive and physiological abnormalities. Although there is extensive research on how exposure affects cognitive development and behaviors, at present little is known about the neurophysiological differences in babies exposed to these substances. This study analyzed EEG data of preterm babies in four treatment groups: not exposed to either substance, exposed to alcohol, exposed to tobacco, or exposed to both substances. Because exposure to alcohol is known to cause neurodevelopmental delays, we hypothesized that babies exposed to alcohol or tobacco would have lower EEG power than those who weren't. Further, we believed the interaction between alcohol and tobacco would exacerbate the effects of alcohol on brain activity. Significant differences were found mainly in posterior brain regions during quiet sleep in alpha and beta frequencies (approximately 7-25Hz). Babies exposed only to alcohol had significantly lower EEG power in these regions, and similar trends were noted in babies exposed to both substances, but with less significant results. These findings are the first to highlight the localized effects of alcohol in neurological functioning. By gaining a greater understanding of alcohol's interference on brain development, we may be able to understand more clearly how alcohol disrupts development, create more robust diagnoses treatments for Fetal Alcohol Spectrum Disorders, and allow mothers to make more informed decisions during pregnancy.

90. Evidence for increased labile zinc in the hippocampus of mast-cell deficient mouse model

Amen Wiqas
Mentor: Rae Silver and Rachel Austin
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Zinc (Zn) is important in neurogenesis, but at excessive levels can cause apoptosis, leading to cognitive impairments. Mast cells are immune cells present in the brain, and found in greatest numbers around the hippocampus, an area containing high concentrations of labile (bioactive) zinc. Since mast cells contain Zn-rich granules and a well-developed mechanism for uptake of Zn ions, we reasoned that they contribute to Zn homeostasis in this area of the brain. In previous work, we found increased labile Zn in the hippocampus of MC deficient mice compared to WT, as measured by Timm staining. Additionally, no change in total Zn was observed in the brain or other tissues between the two genotypes. The goal of the summer was to explore three questions. First, in order to learn more about the localization of bound vs. labile zinc, we performed high resolution X-ray fluorescence to reveal whether the zinc was co-localized with elements associated with proteins, such as sulfur. Second, because all labile zinc is thought to be localized to synaptic vesicles, we also performed immunocytochemistry for zinc transporter ZnT3, a putative transporter of labile zinc into synaptic vesicles. Third, in order to confirm that the total Zn concentrations as measured by the total Zn assays were accurate, inductively coupled plasma mass spectrometry was done. The preliminary results of the ZnT3 antibody staining indicates that there is no significant difference between the two genotypes, consistent with the results of the microarray data. The role of mast cells in the normal functioning of the brain remains elusive, but our data suggests mast cells absorb zinc that has been released by other cells as part of normal cellular processes.

PHYSICS

91. Infrared Nano-Optics of Quantum Materials

Amara B. Jaeger and Maria V. MacArdle
Mentor: Dmitri N. Basov
Department of Physics, Columbia University

Dr. Basov's lab uses infrared spectroscopy beyond the diffraction limit of light to analyze nanoscale phenomena, whose defining features would often be otherwise invisible. The Basov group uses Scanning Near-field Optical Microscopy (SNOM) to examine quantum materials in both time-resolved and time-independent contexts. The lab works most frequently with materials such as graphene, boron nitride and oxides.

92. DA 495: An Aging Pulsar Wind Nebula with Possible Gamma-ray Counterpart

Anna O. Coerver
Mentor: Chuck Hailey
Department of Physics, Columbia University

A pulsar wind nebula is created when a high-mass star dies and forms an isolated neutron star surrounded by a relativistic particle wind. DA 495 is thought to be such an object, although no pulsations have been detected. DA 495 was first detected in the radio band and is characterized by an annular radio morphology with a radio emission dip in the center. DA 495 was detected in the X-ray up to 10 keV by both Chandra and XMM-Newton X-ray telescopes. A study of the Galactic Plane by the HAWC very-high-energy (VHE) gamma-ray telescope revealed a source coincident with DA 495, a source also detected at TeV energies by the VERITAS gamma-ray telescope. The Nuclear Spectroscopic Telescope Array (NuSTAR), the first focusing telescope operating in the hard X-ray band, performed follow-up observations of the region in June 2017. NuSTAR detected DA 495 in the hard X-ray band above 10 keV, as well as two other hard X-ray sources in the field of view. I carried out spectral and imaging analysis of both NuSTAR and Chandra data on DA 495 and used both gamma-ray and X-ray data to study aspects of DA 495 such as morphology, luminosity, age and spin-down power. I am in the process of analyzing the possible central pulsar. I will present results of our study of DA 495.

93. The XENON Dark Matter Experiment: The Outgassing Rate of Teflon

Lin Feng Collins
Mentor: Elena Aprile
Department of Astrophysics, Columbia University

The XENON Dark Matter experiment is one of the most famous dark matter searches currently being conducted in the world. It strives to detect dark matter particles—Weakly Interacting Massive Particles—by observing these particles' collisions with Xenon. In this experiment, I worked with an apparatus that will measure the outgassing rates of Teflon and Torlon. The data collected from this smaller experiment will aid in the building of the dark matter detector for the Dark Matter experiment. The Dark Matter detector needs a reflective, non-porous material to make up the inside of the detector. Data taken from the outgassing system will tell us the way Teflon and Torlon release particles in a vacuum, and which of these materials releases the smallest amount. The setup I worked on involves a vacuum chamber, a residual gas analyzer, and a temperature sensor. Outgassing rate is measured through data from these three sensors. The focus of my part of the project was to build the temperature sensor. The sensor would measure the temperature of a material placed onto a plate inside the vacuum, the temperature of the plate, and the temperature outside of the vacuum. The information gathered from my project will allow the Dark Matter Experiment to run more smoothly and with less interference from unwanted molecules.

94. Next Steps in Energy Reconstruction for Ground-Based Gamma Ray Telescopes

Meera A. Desai
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Department of Physics & Astronomy, Barnard College

High-energy gamma rays are the most energetic form of electromagnetic radiation. When gamma rays from astrophysical sources enter Earth's atmosphere, they produce
extensive air showers that generate Cherenkov radiation detectable by ground-based imaging atmospheric Cherenkov telescopes (IACTs). The Cherenkov Telescope Array
(CTA) is a set of imaging atmospheric Cherenkov telescopes IACTs currently under development. One analysis challenge of CTA data is energy reconstruction—using
information in telescope images to reconstruct the energy of the primary gamma ray. A convolutional neural network (CNN) is a machine learning algorithm designed to mimic
the brain's process of visual learning. CNNs show great promise for improved image recognition and are used in commercial applications, including at Facebook and Google. I am adapting Google's InceptionV3 CNN to address energy reconstruction with CTA
data. Through a process of training on hundreds of thousands of simulated CTA images, the algorithm will automatically learn the optimal parameters for calculating the gamma ray energy from the telescope images. The study of astrophysical sources at gamma ray energies yields novel insights into the most powerful cosmic particle accelerators, including jets associated with supermassive black holes, shock waves in supernova remnants and the nebulae surrounding energetic pulsars, and the complex physics of Xray binary systems. Very-high-energy gamma rays can also probe some of the most important questions in particle physics and cosmology: the search for dark matter, Lorentz invariance violation, and the strength of the magnetic field in intergalactic space.

95. Observing Rare Blazars: Examining the nature of very-high-energy gamma-ray emission from the AGN PKS 1222+216 and 3C 279

Sharleen Price
Mentor: Reshmi Mukherjee
Department of Physics and Astronomy, Barnard College

Active Galactic Nuclei (AGN) is the compact emitting region at the center of a galaxy that is powered by a supermassive black hole. They are one of the various types of sources observed by VERITAS (Very Energetic Radiation Imaging Telescope Array System): an array of four ground-based gamma ray telescopes. Surrounding material in AGN can orbit and fall into the black hole creating an accretion disk and jets that radiate at all energy wavebands, making AGN extremely luminous. Blazars are a type of AGN that emit relativistic jets of ionized matter towards Earth's line of sight at speeds close to the speed of light. The sources I am studying, PKS 1222+216 and 3C 279, belongs to the subset of blazars called FSRQs – Flat Spectrum Radio Quasars. FSRQ's are interesting because they are very rarely observed in the very high energy TeV range (100 GeV to 10 TeV). In fact, only six FSRQs have ever been detected in this range by high-energy gamma ray telescopes. Additionally, these sources also exhibit very short-scale variability that challenges the present model of blazars. Very short time scales imply very small emission regions in the blazar jets. I am studying these sources in hopes to constrain the size of the emission region and further contribute to our understanding of particle acceleration in blazar jets.

96. Primordial Magnetogenesis: Placing Constraints on the GMFs and EBL through the observation of BL Lac 1ES 0229+200

Miriam Ramirez
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Department of Physics and Astronomy, Barnard College

In my research I looked at data from a VHE (Very High Energy) Blazar source BL Lac 1ES 0229+200, which over the years has become a primary source in placing constraints on the Intergalactic Magnetic Fields (IGMFs) and the Extragalactic Background Light (EBL). Scientists have found evidence that the magnetic fields in intergalactic space are not negligible and that cosmic voids are filled with extremely weak magnetic fields. The origin of these primordial IGMFs still remains a mystery. The Galactic Dynamo can explain the presence of large scale IGMFs through the amplification of weak magnetic seeds to immense scales; however, the true origin of these magnetic seeds is still unknown. Furthermore, current measurements of the Extragalactic Background Light (EBL) densities are plagued with large uncertainties. Observations of blazars at TeV energies help us learn more about both the EBL and the IGMFs. Blazars are extragalactic objects thought to be powered by super massive black holes that could be a billion times more massive than the Sun. Through observations with Very Energetic Radiation Imaging Telescope Array System (VERITAS) Cherenkov telescopes we can place constraints on the strengths of IGMFs and as well as EBL. In my work this summer, I analyzed data on the blazar 1ES 0229+200 in an effort to learn more about these primordial fields.

PSYCHOLOGY

97. The Impact of Labels: Measuring dehumanized language for people in prison

Carly J. Lenniger
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Department of Pyschology, Columbia University

The Prison Policy Initiative recently released a 2017 report finding that 2.3 million people of the US population are currently incarcerated. Additionally these people in prison (PIP) are victims of mistreatment such as violence due to the use of excessive force and severe neglect in the form of moral exclusions and disengagement by prison guards and other staff (Blackler, 2015; Gullapalli, 2015). The Center for Justice is attempting to put an end to this abuse by analyzing labels and the stigmas they carry for PIP. Does the language used to identify PIP carry a negative and dehumanizing stigma? To answer this question the study used Haslam's model of dehumanization to create a survey measuring each of his characteristics of human uniqueness and nature vs. mechanistic and animalistic dehumanization. Participants answered on Likert scales their perception of whether or not these traits were attributed to 14 different labels, including the three prison related terms of interest (inmate, convict, prisoner). Once the survey circulates, the lab will analyze the data to determine if prison-related labels received low, average, or high levels of dehumanization. If our hypothesis was correct and language regarding PIP is negative/dehumanizing, the next question is whether or not using different (non-dehumanizing) language can change the public's perception of PIP and the degree to which they legitimize and/or ignore inhumane treatment. This provides a springboard for enacting strategies to eliminate the prevalent abuse currently occurring in US jails and prisons.

98. Iconicity in an Emerging Sign Language Lexicon: How learning changes language

Charlotte Quincoses
Mentor: Ann Senghas
Department of Psychology, Barnard College

How does language reflect human cognition? This project examines the role of *iconicity*: the physical resemblance of a symbol to its referent, as in representing a ball with a circle. Using an emerging sign language in Nicaragua (NSL) this study considers whether the prevalence of iconicity in sign language is a result of its usefulness in language creation or language learning. If so, does language creation favor the same type of iconicity as learning? In previous work in our laboratory, we compared signs from 2007 and 2017 produced by a first-cohort (C1) creator of NSL to those produced by a second-cohort (C2) learner. A majority of signs exhibited iconicity with the C1 signer showing more pantomimic type of iconicity, and C2 showing more perceptual type signs. Furthermore, the paired comparisons revealed that as signs pass down from first to second cohort, they decreased in iconicity; this effect was entirely due to pantomimic signs. Iconicity did not decrease overall from 2007 to 2017. Currently, we continue to explore the driving mechanisms for this observed loss in iconicity by adding another pair of C1 and C2 signers, using only signs elicited from 2007 to measure whether the effect holds as we add signs and signers. If the pattern does hold, the higher rate of pantomimic signs in C1 would point to its usefulness in language creation, while perceptual signs in C2 signers reveal its use in language learning.

99. Self control is associated with ADHD symptoms in children with Autism

Danielle Dennis
Mentor: Rebecca Jones
Department of Psychiatry, Weill Cornell Medicine

Approximately a third of individuals with Autism Spectrum Disorder (ASD) also meet criteria for Attention Deficit/hyperactivity Disorder (ADHD), demonstrating a significant overlap between the two disorders. This study seeks to understand how symptoms of ADHD in children with ASD impact self control to different stimuli. Caregivers completed the Strengths and Weaknesses of ADHD Symptoms (SWAN) to assess children's attention and hyperactivity behaviors. Twenty-eight children with ASD and 27 typically developing (TD) children completed a Go/NoGo task that had different categories of stimuli (a child's special interest, non-interests, colored shapes, and happy and neutral facial emotions) and impulsivity was measured with d'. Correlations were performed between scores on the SWAN and d' to the five stimulus categories. There was a significant relationship between the SWAN and d' to a child's special interest in both children with ASD and TD children, showing that children with more ADHD symptoms were more impulsive to images of their interest. No other correlations survived multiple comparison testing. The results suggest that regardless of diagnosis, children with more symptoms of ADHD, had the most difficulty accurately and non hastily responding to an image of their interest compared to social images or images of non-interest. This data is consistent with previous findings that children with ASD are more influenced by their special interests. Because interests were the only stimuli to show an association with ADHD symptoms, it suggests that there is something unique about these stimuli compared to other images, including social images.

100. Risks and Benefits of Overdose Education and Naloxone Prescribing to Heroin Users

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Over-intoxication related to prescription and illicit opioid overdose is a major cause of deaths worldwide. Opioid overdose is also a significant concern in the New York City area. Emergency department visits related to prescription opioids nearly doubled between 2005 and 2009 (from 55 to 110 per 100,000 New Yorkers). In response, several states have passed legislation authorizing programs where non-medical persons are given brief education in recognizing the signs of opioid overdose, and how to administer the opioid antagonist naloxone.) In 2005, New York passed similar laws allowing New York State Department of Health-registered organizations to dispense naloxone to drug users and drug non-users for the purpose of reversing opioid overdose in another person. However, empirical data on the effectiveness of naloxone programs in reducing fatal overdoses, as well as the complications associated with non-fatal overdoses, is critically needed. This study will allow us to evaluate the effectiveness of current overdose prevention programs in NYC, and how we can improve upon their current practices. Those who are eligible for the study will receive a standardized 15-minute training on how to recognize signs of an opioid overdose and how to properly administer naloxone. Afterwards, subjects will come in during various time points where they will be given eight questionnaires regarding their general health, substance use, overdose knowledge. We hypothesize that additional psychosocial intervention will improve overdose prevention outcome measures, and we also hypothesize that the occurrence of naloxone-related adverse events will be minimal.

101. Investigating overestimation bias in mental temporal summation

Jessica E. Tschida
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Time is a pervasive element of life and behavioral functioning is dependent on accurate judgments. However, despite the importance of the ability to understand temporal durations, research regarding how temporal durations are represented and manipulated is limited. Thus, the current study tested healthy human participants on a computer based temporal reproduction task in which they were required to judge different time intervals both independently and in combination. Specifically, participants were presented with two durations (1.5s and 3s) signaled by visual stimuli and were then instructed to reproduce the duration of a single stimulus or the duration of the two stimuli added together. In serial interval trials, participants initiated the presentation of two successive stimuli for set durations and then reproduced the duration of either the first or second stimulus. In summation trials, participants reproduced the duration of the sum of the two stimuli. In control trials, participants initiated and reproduced the duration of a single stimulus with target intervals corresponding to all possible durations in the serial and summation reproduction tasks. It is hypothesized that participants will overestimate the sum of temporal durations as is found in numerical and spatial domains (Hubbard, 2014). Future research will investigate other forms of temporal arithmetic to further an account of how time is represented and mentally manipulated in such processes.

102. The Role of Distress Tolerance in Relationship to Trauma and Marijuana Usage

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Individuals often report smoking cannabis to cope with anxiety and other psychological discomfort and are less able to handle stress. As part of a larger ongoing study, we examined distress tolerance in relationship to self-reported traumatic experiences, and problems with cannabis in 18 (10 females/ 8 males) psychologically and physically healthy recreational cannabis smokers. The Distress Tolerance Scale (DTS), a self-report measure assessing the capacity of a person to experience and withstand negative psychological states, was used to measure distress tolerance. The Traumatic Assessment for Adults (TAA) was used to record number of lifetime traumatic experiences, and the Marijuana Problem Scale (MPS) was used to examine problems participants had with marijuana. It was hypothesized individuals with low distress tolerance scores would be more likely to endorse problems with cannabis. It was additionally hypothesized that individuals with more traumatic experiences would have lower distress tolerance scores. Overall there was a significant negative correlation between distress tolerance and problems with cannabis, as well as a negative correlation between distress tolerance and traumatic life events endorsed. Further, for women, there were significant negative correlations between DTS scores and MPS scores, as well as DTS scores and TAA scores. For males, DTS was negatively correlated with TAA, but not correlated with MPS. Thus, people with low distress tolerance are more likely to report problems with cannabis, and have experienced more traumatic life events. Understanding cannabis abuse could help create prevention problems for cannabis abuse, specifically for people with traumatic histories, or those with low distress tolerance.

103. Eye-tracking Spatial Cognition in Early Childhood

Sara Hameed, Catherine Sufiyarova, Zofia Trujillo, Eloise West
Mentor: Koleen McCrink
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Spatial-numerical associations take the form of a mental number line (MNL), with small numbers on the left and large numbers on the right. This MNL is associated with formal mathematical prowess in childhood, and is driven by an inborn tendency to privilege the left side of space when processing a scene. This left-side bias shifts by age four, to echo the starting direction of the script that is most prominent in the child's culture. But it is unclear exactly when, or why, this shift occurs. In the present study, we test the hypothesis that because infants exhibit a leftward bias regardless of enculturation, and preschoolers exhibit culture-driven SAs, SAs are undergoing a flexible period in toddlerhood in which both the left side and right side of space are equally privileged. Using an eye-tracking device, we examined gaze patterns to detect directional biases among infants and toddlers (N=11, M_{age}=23.9 *mos*). Participants were shown a series of trials wherein a baby chick hides in the second location from the bottom in a set of five locations. The locations are then occluded and rotated 90^{o}, at which point the participant is prompted with the question "Where is the baby chick?" We then coded whether the participants gaze at the second location from the left (indicating a leftward search bias) or right (indicating a rightward search bias). Preliminary data support our hypothesis, with infants preferentially searching the left side of space, and toddlers equally searching the left and right sides.

104. Imitation of Spatial Structuring in Toddlers and Preschoolers

Sara Hameed, Catherine Sufiyarova, Zofia Trujillo, Eloise West
Mentor: Koleen McCrink
Department of Psychology, Barnard College

Adult humans associate mental concepts with spatial locations, and so asymmetrically, with initial items in a string of information (such as a number or letter sequence) linked to the left side of space, and final items to the right. Developmental work has found that young schoolchildren who have especially "rigid" preferences for these asymmetric spatial associations have better formal mathematical understanding. The current study aims to evaluate the degree to which toddlers and kindergarteners recall and resist different types of structure, in order to gauge the degree of spatial rigidity in early childhood for basic numerical concepts. The participants were 12 children (N=12) ages 5-6 years (n=8) and 3 years (n=4), recruited from local children's museums in New York City. The children participated in an activity in which they watched an experimenter place colored, lettered, or numbered chips into wells from left-to-right or right-to-left, and subsequently had to imitate this placement to complete the task. It was hypothesized that children would imitate the order and direction of placements for trials with number or letter labels, which are very highly ordered in daily life, better than those with color labels. Toddlers were predicted to show less bias in terms of directionality than preschoolers, who would be more likely to "flip" right-to-left layouts to left-to-right layouts. The results partially supported the hypothesis, with all children maintaining the order better on numerical than color blocks. However, toddlers showed a lower ability to resist left-to-right bias.

105. Parental Transmission of Spatial Structure

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Mentor: Koleen McCrink
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Adults possess spatial associations (SAs), in which we mentally map the initial items in a string of information to the left, and the final items to the right. SAs are present at birth, but become influenced by cultural and linguistic factors. The current study evaluates the degree to which parents alter these SAs by treating them as social "conventions" when presenting spatial structure to their children. 3- and 5-6 year-olds were recruited with their parents from children's museums in New York City. The child-parent dyad participated in an activity in which they had to work together to construct a spatial layout to complete a task. The task involved three distinct types of information for the parents to structure for their child: numerical, alphabetical, and colored items. We hypothesized that younger children will receive more conventionalized instruction overall, as parents work to socialize their children to cultural information, and that children of all ages will receive more conventionalized instruction on numerical and alphabetical trials. Early results are promising (N = 12). Our findings indicate a trend of more conventional attitudes transmitted to younger children (3-year-old children) than older children (5- and 6-year-olds), with parents and caregivers using more explicit language cues that suggest social conventionality around spatial ordering. For older children, more suggestive and flexible language was used over imperative directions. The explicit language used for younger toddlers and older children occurred most often among numerical trials, indicating a stronger directional spatial rigidity with numerical-spatial associations as opposed to other SAs.

106. Neural Activation Associated with Conditioned Inhibition Differs Across the Rostral Caudal Axis

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Inhibitory conditioning occurs when a subject learns that a certain response will not be rewarded during a specific cue. Learned inhibition is crucial to understand due to its important role in guiding social adaptation and survival in nature. Without learned inhibition, it would be impossible allocate behavior in optimal ways. Lack of inhibitory control is a symptom of many psychological disorders such as OCD, ADHD, and schizophrenia. In order to study the neural bases of inhibition, mice first learned to press a lever to earn a milk reward. Next, a subset of mice were exposed to a conditioned inhibition procedure in which they learned that the reward was unavailable during an auditory tone cue (CS-). For the rest of the mice there was a random relationship between the tones and reward. These mice continued to be able to lever press for milk rewards during the tone cue and the inter-trial interval (ITI) and were matched to the conditioned inhibition group with respect to exposure to tones or rewards. The mice in the conditioned inhibition group learned to inhibit their responding during the CS-. Subjects were sacrificed after either session 3 or 15. Forty μm slices were collected and analyzed using immunohistochemistry. Neural activity in the prelimbic (PL), infralimbic (IL), and insular cortex were examined via c-fos expression due to their involvement in fear inhibition (Vidal-Gonzales et al, 2006), learned appetitive inhibition (Ragozzino, 2007), and learned safety (Christianson et al., 2008). The late training (15 day) conditioned inhibition mice were the only group that significantly inhibited responding to the CS- and therefore learned conditioned inhibition. In mice sacrificed after 3 days of training (early groups), there were no significant differences in c-fos expression. However, significant comparisons were found among mice sacrificed after 15 days (late groups). Compared to the control group, there were significant differences in cell activity in the Bregma region of 1.94-1.98 in the IL. In the PL, the significant Bregma regions were 1.94-1.98 and 1.74-1.78. In the Insula, the significant Bregma region was 1.54. Knowing the specific Bregma regions in each area of the brain involved with conditioned inhibition, we can now use DREADDs to inhibit these areas to see if they play a functional role in the learning and/or expression of conditioned inhibition.

107. Pubertal- and sex-dependent changes in cell proliferation in the dentate gyrus of rats

Alina Siddiqui
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Pubertal development is associated with many changes in the structure and function of the central nervous system, including significant decreases in the rate of cellular proliferation in the dentate gyrus of the hippocampal formation. These studies examining pubertal-related changes in hippocampal cellular proliferation have largely focused on male rats. In adulthood, sex differences in cell proliferation are present in this species, but the influence of sex on pubertal changes in this parameter are unknown. Thus, we examined cellular proliferation, as measured by Ki-67 immunohistochemistry, in the dentate gyrus in the dorsal hippocampal formation in pre-pubertal (30d), mid-pubertal (45d) and post-pubertal (70d) male and female rats. We found significant pubertal decreases in the number of Ki-67 -positive cells in both males and females, but this decrease was significantly greater in males than females. This sex difference is driven by the significant difference in the number of Ki-67-positive cells between the 30d-old males and females, with males showing significantly higher levels of cellular proliferation compared to females. These data show both pubertal- and sex-dependent changes in hippocampal cellular proliferation in rats. Given the widespread influence of hippocampal cellular proliferation on neurobehavioral functions and dysfunctions, future studies will need to address the implications of these differences. Moreover, additional studies are being conducted to assess if these differences are specific to the hippocampus or if they occur in other proliferative zones of the brain, such as the subventricular zone.

108. Impact of Mild Sleep Restriction on Performance in Adults

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Sleep duration has been proven to be inversely related to obesity risk, as short duration sleepers are at increased risk of large weight gain over time. However, despite the support that sleep restriction leads to an increased level of energy intake, it is unsure whether the positive energy balance will be observed with less severe sleep restriction prolonged for a longer duration. Thus, this clinical study aims to see how mild sleep restriction affects overweight people's (BMI range: 25-29.9) mood and physical and cognitive performance. One specific aim is to see the effects of sleep restriction, compared to habitual sleep, on food choice and energy intake. We hypothesize that mild sleep restriction (-1.5h/night), over a period of 6 weeks, leads to a positive energy balance and increased adiposity compared to another habitual sleep 6-week period of a within-subject, crossover study. Sleep restriction will increase ghrelin levels, resulting in increased appetite, rewarding evaluation of food, and energy intake. Sleep duration, efficiency, and physical activity level are monitored daily by an actigraphy watch. Ghrelin, leptin, PYY, and GLP-1 levels are measured by blood samples with ethylene diamine tetra-acetic acid- aprotonin. Total body adiposity is assessed using magnetic resonance imaging at the beginning and end of each phase. Evaluation of food and cognitive performance is measured by neural responses to stimuli images of objects and food items, assessed by functional MRI after both 6-week phases. This study is still in the early data collection phase, thus conclusions have not yet been extrapolated.


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