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Trinity College

NINTH ANNUAL
SUMMER RESEARCH SYMPOSIUM

Presentations

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NINTH ANNUAL
SUMMER RESEARCH SYMPOSIUM
TRINITY COLLEGE

TABLE OF CONTENTS

Poster # **Title**

BIOLOGY

9. **THE EFFECT OF ENDOPLASMIC RETICULUM (ER) STRESS ON LIPID COMPOSITION IN OLIGODENDROCYTES**
Michael McQuiston ‘16

10. **UNDERSTANDING THE RATE OF SEGMENT ADDITION IN ARTHROPODS BY LOCATING PULSES OF MITOSES IN *TRIBOLIUM CASTANEUM* EMBRYOS**
Heidi Pi ‘14

11. **IS ELONGATION AND SEGMENT PATTERNING INDEPENDEDNT PRCOCESSES IN NORMAL GROWTH OF A CRUSTACEAN, FAIRY SHRIMP?**
Niranjana Pokharel ‘15

CHEMISTRY

12. **DISCOVERY OF A DIMERIC BY-PRODUCT IN THE PREPARATION OF A TUNGSTEN BIS-ALKYNE COMPLEX**
Lauren Davidson ‘16

13. **SURFACE CONCENTRATION OF FORMIC ACID AT THE LIQUID VAPOR INTERFACE**
Jeff Pruyne ‘15

14. **SYNTHESIS AND CHARACTERIZATION OF CYCLIC TUNGSTEN BIS-ALKYNE COMPLEXES DERIVED FROM HEXAMETHYLENEDIAMINE AND m-XYLENEDIAMINE**
Edgar Soto ‘15

15. **CYCLIZATION OF TERMINAL DIALKYNES BY COORDINATION WITH TUNGSTEN**
John Stiller ‘14

ENGINEERING

16. **THE CLOGGING CASCADE OF AN ARRAY OF MICROCHANNELS**
Erin Barney ‘15

17. **IGNITION STUDY OF SUPERSONIC FREE STREAM JETS USING SHOCK TUBE**
Christian T. Firsching ‘15, Binod Giri ‘15, Barok Imana ‘16

18. **WAVELET BASED ALGORITHM FOR DATA COMPRESSION**
Jin Feng Liu ‘14

19. **HUMAN ARM MODEL AND PRATT TRUSS BRIDGE MODEL**
Jake Mevorach ‘16, Hang Yang ‘16, Khari Jarrett ‘16

20. **NEW VISION SYSTEM AND NAVIGATIONAL ALGORITHM FOR AN AUTONOMOUS GROUND VEHICLE**
Hokchhay Tann ‘14, Bicky Shakya ‘14, Alex Merchen ‘14, Abhishek Khanal ‘15,

Jiajia Zhao ‘15, Ben Williams ‘15

ENVIRONMENTAL SCIENCE

21. THE EFFECT OF CLEAR CUTTING ON SUB-ALPINE FOREST SOIL NUTRIENTS AND TRACE METALS WITHIN THE WHITE MOUNTAIN NATIONAL FOREST, NEW HAMPSHIRE
Justin Beslity ‘15, Daniel Hong ‘15

22. MAGNETIC CHARACTERIZATION OF LAKE SEDIMENT TO RECONSTRUCT STORM FREQUENCY RECORDS IN NEW YORK
Jami Cogswell ‘16

23. A POLLEN DIAGRAM FROM LAKE LOUISE, CENTRAL CONNECTICUT
Madeline Foley ‘14

24. SYNERGISM IN TOXICITY OF MIXTURES OF PHARMACEUTICALS TO *DAPHNIA MAGNA*
Airelle A. James ‘14

25. DEGRADATION OF DISSOLVED ORGANIC MATTER BY MICROBIAL AND PHOTOCHEMICAL PROCESSES IN TEXAS RIVERS
Jessica Smith ‘14

MATHEMATICS

26. GENERALIZATIONS OF HYPERBOLIC TRIGONOMETRY
Greg Convertito ‘16

27. TAXICAB GEOMETRY AND MASS TRANSIT DISTANCE
George Thekkedath ‘16

NEUROSCIENCE

28. INVESTIGATING THE RELATIONSHIP BETWEEN BEHAVIORAL AND ELECTROPHYSIOLOGICAL ASPECTS OF PM IN INDIVIDUALS WITH TRAUMATIC BRAIN INJURY AND HEALTHY INDIVIDUALS
Erin Aisenberg ‘16, Tessa Bloomquist ‘16

29. THE EFFECTS OF CAFFEINE ON THE SYNAPTIC PLASTICITY IN THE HIPPOCAMPUS OF RODENTS
Nicholas Bellas ‘16, Alison Callegari ‘14, Yasmine Delgado ‘14, Julia Duggan ‘16, Georgia McAdams ‘14, Venus Nunez ‘14, Jenna Park ‘16

30. THE EFFECTS OF TWO DIFFERENT KETOGENIC DIETS, VARYING IN NUTRIENT CONSTITUTION, ON THEIR ABILITY TO ALLEVIATE AUTISTIC SYMPTOMS IN A MOUSE MODEL
Subrina Bisnauth '15, Alex Suarez '16

31. THE EFFECTS OF ALCOHOL USE ON COGNITION IN COLLEGE STUDENTS
Sharmy Dhaliwal '16

32. EFFECTS OF GLIAL-DERIVED FACTORS ON APOPTOSIS IN NEUROBLASTOMA CELLS
Anne Do '16, Livia Wyss '16

33. METFORMIN AND A MODERATE KETOGENIC DIET: THE EFFECT ON BLOOD CHEMISTRY AND BEHAVIOR ON A MOUSE MODEL OF AUTISM
Jessica Fortin '14

34. THE EFFECT OF THE KETOGENIC DIET ON THE POLY (I:C) MOUSE MODEL OF AUTISM
Michelle Murphy '14

35. SUPPLEMENTATION OF THE KETOGENIC DIET WITH EVEN- AND ODD-NUMBERED MEDIUM CHAIN TRIGLYCERIDES IN A MOUSE MODEL OF AUTISM
Lisa Saa '14

PHYSICS

36. STUDY OF ULTRAFAST DYNAMICS IN NANOSCALE
Pratistha Shakya '15

BIOLOGY

1.
EFFECT OF SIMPLE SOCIAL STIMULI ON BEHAVIOR AND NEUROGENESIS IN THE TELENCEPHALON OF WEAK ELECTRIC FISH *APTERONOTUS LEPTORHYNCHUS*
Hamdi Abdi '16
Faculty Sponsor: Kent Dunlap

Electric fish are prime candidates for studying the effects of social stimuli on neurogenesis because their electrocommunication signals are influenced by brain regions that have abundant neurogenesis. In this experiment, we examined the forebrain of the brown ghostknife fish for evidence of neurogenesis, a region homologous to the mammalian hippocampus and previously disregarded in studies of the fish brain. Immunohistochemistry for BrdU was performed in the forebrain of fish previously sacrificed in the spring, which enabled us to see that the forebrain was in fact a source of socially induced neurogenesis. It is currently known that social stimuli cause neurogenesis and behavioral change, but it is unknown whether neurogenesis is also a cause of the social change.

2.

USING A COMPUTATIONAL MODEL TO EXPLORE SEGMENT ADDITION DURING DEVELOPMENT IN THE FLOUR BEETLE *Tribolium castaneum*

William Blaine ‘15
Faculty Sponsor: Terri A. Williams

While body segment development has been intensively studied in fruit flies, Drosophila melanogaster, D. their segmentation is atypical: segments are formed simultaneously from an early syncytium. However, most other arthropods- myriapods, chelicerates, crustaceans, and insects –form their segments sequentially from a cellularized “growth zone,” an elongating region in the posterior part of the embryo. Because little is known about how cell behaviors (such cell division and movement) drive segment addition in most arthropods, we have created an in silico model (via Compucell3D software and python script files) of germband elongation using actual measurements from the growth zone in the red flour beetle, Tribolium castaneum, over the 16-18 hour time period after egg lay. Using Compucell3d software, simulated cells received a programmed set of parameters to allow them to grow, divide, follow chemical signals, and exhibit motility. We model a 2 hour period during Tribolium segment addition (16 to 18 hours after birth) during which segments are added rapidly, doubling the number of segments from 6 to 12. Using dimensional measurements and transect cell counts of the 16 hour growth zone (obtained from images of DAPI-stained germbands), an initial cell field was generated. Furthermore, counts of rates of mitosis during the 16-18 hour timeframe indicated that cell growth plays a minor role at that stage of development, while cell rearrangement drives the drastic elongation that occurs between 16 and 18 hours. Thus, an accurate and realistic model of segment addition had to include prevalent cell motility, but little cell growth. By including biases in the direction of motility, a working model was produced that could successfully use a 16 hour initial condition to generate cell fields similar to the terminal portion of the 18 hour germband. After the completion of a general model of segment addition, cell growth and migration parameters can be adjusted to produce exact 18 hour cell fields, and thus, investigate how cellular behaviors produce the rapid segmentation seen during the 16-18 hour time period.

3.

TEMPERATURE ACCLIMATION OF THE NERVOUS SYSTEM IN WEAKLY ELECTRIC FISH, *APTERONOTUS LEPTORHYNCHUS*

Hannah Brickley ‘14, Hamdi Abdi ‘16, Caroline Blanchard ‘13
Faculty Sponsor: Kent Dunlap

Although global climate change will likely cause behavioral change in animals, the mechanisms by which temperature influences neural processes that control behavior are not well understood. The electric signals of weakly electric fish, which are used in communication behavior, are highly temperature sensitive and provide a direct insight how temperature change affects the nervous system. Our study explores whether neural circuits in the electrocommunication system undergo thermal acclimation in response to a long-term temperature change in weakly electric fish, *Apteronotus leptorhynchus*. Twenty fish were housed for >20 days in either warm water (27.8°C) or cool water (25.6°C). Six random test fish were chosen and transferred from the cool tank to the warm tank and then back to the cool tank. Between each transfer, data were collected one day after the switch and then again 10-11 days after the switch. During data collection, the fish were held in a test tank where the water was cooled from 30°C to 22°C and the voltage of the electric organ discharge was recorded every two degrees. For each fish, we graphed the relationship between the electric discharge frequency and temperature. Compared to control fish kept at constant temperature, fish that were transferred from cold to warm water showed an increased slope (Q10) and decreased y-intercept. Fish transferred from warm to cold water showed a decrease in slope (Q10) and increase in y-intercept. Results were only statistically significant at days 10-11 of acclimation. These results suggest an acclimation to long-term temperature change and show the ability of the fish to maintain a relatively constant electric discharge despite temperature change.

4.

CREATION OF SERRATE LIGAND GENE CONTRUCTS FOR ACTIVATION AND INHIBITION OF THE NOTCH SIGNALING PATHWAY

James Curlin ‘15
Faculty Sponsor: Robert J. Fleming

The cell signaling pathway known as Notch is a highly conserved mechanism of cell differentiation that exists in an extremely large range of animals, including humans. This pathway is regulated by two ligands known as Serrate and Delta, which can either inhibit or activate the activity of the pathway by interacting with the Notch receptor. Serrate’s ability to inhibit Notch is dependent on its location relative to the Notch receptor. When both Serrate and Notch are present on the same cell, the Notch receptor is inhibited. When located on separate cells, Serrate functions in the activation of the *Notch* pathway. A series of EGF-like repeats within the Serrate molecule appear to be primarily responsible for the inhibition, as shown in a previous study when the deletion of repeats 4, 5 and 6 in the Serrate molecule resulted in a lack of inhibition of the Notch receptor. Further studies show that when repeats 4-6 were moved in between repeats 11 and 12, activation was retained, but inhibition was still lost. A construct of the Serrate molecule is currently being developed, which will move the EGF-like repeats 4, 5 and 6 in between repeats 7 and 8. The results of this construct will determine if the location is a major factor in the inhibition of the Notch molecule.

5.
ACETYLCHOLINESTERASE IN THE BRAIN OF THE CHINESE MUD SNAIL: MOLECULAR WEIGHT AND FORMATION OF POLYMERS
Xiaomeng Deng ‘16
Faculty Sponsor: Charles Swart

The cholinergic neurotransmitter system is the most dominant system in vertebrates controlling motor systems as well as various aspects of cognition. In invertebrates this is not always the case. In gastropods acetylcholine is found only in the central nervous system. I have been studying the enzyme acetylcholinesterase, which removes acetylcholine from the synaptic cleft in the brain of the Chinese mud snail, *Cipangopaludina chinensis*. This summer I developed several methods in an attempt to determine the molecular weight of the monomeric form of AChE. In *C. chinensis* AChE in the brain is only found in membrane bound form and when released from the membrane by treatment with detergent the subunits combine together to form large polymers. I altered several aspects of sample preparation and polyacrylamide gel electrophoresis to eliminate this polymerization: a) using freshly acquired brain samples without storage in the freezer b) using the same buffer (Tris) as the PAGE and avoiding the commonly used phosphate buffer, c) Separating the enzyme from other brain proteins in a native PAGE at a very low voltage (35 to 70 V) over 4 to 6 hours, d) Recovering the bands that show enzyme activity from this initial gel and running it again in denatured state on standard PAGE. Unfortunately the concentration of enzyme recovered in this process is too low to detect with standard coommassie staining. I am currently working on methods of protein isolation prior to PAGE including affinity gel filtration and ammonium sulfate precipitation.

6.
CELL DIVISION CYCLE COUNTS AND ELONGATION IN RED FLOUR BEETLE
Sara Khalil ‘15
Faculty Sponsor: Terri A. Williams
Non-Trinity Sponsor: Lisa Nagy, Ecology & Evolutionary Biology, University of Arizona

Segmentation is a key feature of arthropods and the process by which segments form has been well studied in the model system, the fruit fly *Drosophila*. Segmentation occurs simultaneously in *Drosophila*. By contrast, most arthropods add segments sequentially from what is assumed to be a growth or proliferative zone at the posterior region. Molecular events that establish and maintain the growth zone and the varying mechanisms of elongation and segmentation among arthropods aren’t well understood. Therefore, a model is needed to explain how sequential segmentation occurs in arthropods. *Tribolium castaneum*, commonly known as red flour beetle, is a non-drosophilid arthropod that undergoes a process of segmentation and elongation that differs from that of the generalized *Drosophila* model. This project focuses on determining if cell division, cell rearrangement and cell shape change, or both are important in explaining the mechanism in which elongation occurs. A fate map of the cellular blastoderm was generated and used to

estimate numbers of cell divisions in clones. This made it important to know what cell cycle the blastoderm of each clone was in. I made cell division cycle counts using confocal images of DAPI (nuclear stain) early staged embryos. Differences in cell division cycles were quantified using software, Image J, by taking measurements such as the total number of nuclei and inter-nuclear distance. The cell cycle stage was then deduced using a standard chart that correlated total number of nuclei to the cell division cycle. Determining number of cell cycles that occur before the germ band starts to form provides information about the number of divisions the mapped clones undergo in the process of germ band formation and elongation. The collected data more or less supported *Handel*'s claim that Tribolium embryos go through 13 cell division cycles before they start germ band movements.

7.

SPHINGOSINE KINASE-2 INHIBITOR DIMINISHES RENAL INFLAMMATION/ FIBROSIS IN RESPONSE TO UNILATERAL URETERAL OBSTRUCTION

Lorena Lazo de la Vega '14
Non-Trinity Sponsors: Shobha Thangada, Fernando Ferrer, Department of Vascular Biology, University of Connecticut Health Center, Farmington CT

Renal injury and fibrosis affects 1 in 1000 people due to a urinary tract obstruction caused by blood clots, tumors, defects, or excess fibrous tissue. Previous studies from Dr. Ferrer's lab have shown that sphingosine kinase-2 (SphK-2) deficient mice have diminished renal injury after being subjected to unilateral ureteral obstruction (UUO) surgery. In the present study, we aimed to study if SphK-2 inhibitors can diminish the renal injury in mice using the UUO model. Therefore, six to seven week old male C57BL/6 mice were treated with either vehicle, which is the control group, or with a novel Sphk-2 inhibitor SLR080811 (3 mg/kg dose) through intra peritoneal injections for three days. Inflammation and renal fibrosis was then induced with ureteral obstruction by ligating the right ureter. The qRT PCR data of inflammatory cytokines reveal that there is diminished inflammation in the kidney of SK2I treated mice after UUO surgery. The kidneys of SK2I treated mice showed decreased levels of α SMA and vimentin by western blot analysis which is indicative of diminished renal injury/ fibrosis. Since, there were indications of less injury in the kidneys, we hope that further manipulation of the S1P signaling pathway may lead to a novel class of therapeutic drugs to treat chronic kidney disease.

8.

INHIBITION OF THE CELL CYCLE IN *TRIBOLIUM CASTANEUM* USING HYDROXYUREA INJECTIONS

Raymond Li '14
Faculty Sponsor: Terri A. Williams

Arthropods have the largest number of species of any phylum and their diversity rests mainly on their segmented body plan. Most information about how arthropods develop their segments has been based on the fruit fly, Drosophila. However, Drosophila is atypical because it develops its segments simultaneously whereas most arthropods develop segments sequentially from a posterior growth zone. There are two main ideas about how the growth zone elongates as segments are added: high rates of cell division or a significant amount of cell migration. . To evaluate the relative role of these two cell behaviors, we have been studying the arthropod Tribolium castaneum since it develops using sequential segmentation. Tribolium undergoes two period of rapid germband elongation and segment addition during which we hypothesize that cell division plays a minor role. To test this, we blocked cell division during one of these phases using a cell cycle inhibitor hydroxyurea (HU) to inhibit cell mitosis. Previous research has stated that HU was able to inhibit cell division in Drosophila. We first attempted to block cell division by direct soaking of eggs in a HU solution but found no decrease in the amount of mitosis compared to controls. We

then developed a technique to inject HU directly into the eggs. We observed that injecting HU into the embryos of Tribolium inhibited cell mitosis in comparison to the control groups. However, we were unable to check whether or not cell cycle inhibition lead to any changes in segmentation since the collected germbands were all broken. For the future, we hope to continue with the HU injections to test whether cell division is required for embryo elongation.

9.

THE EFFECT OF ENDOPLASMIC RETICULUM (ER) STRESS ON LIPID COMPOSITION IN OLIGODENDROCYTES

Michael McQuiston '16
Faculty Sponsor: Hebe Guardiola-Diaz

Myelin, a lipid and protein-rich membrane in the nervous system, engulfs the axon of a neuron forming a sheath around it. This sheath is essential for homeostatic neuronal function, and its synthesis is dependent on the various biochemical changes occurring in oligodendrocytes throughout differentiation. In an effort to further understand the Erk1/2 MAPK and mTOR pathway and its involvement in proper oligodendrocyte differentiation, endoplasmic reticulum (ER) stress was chemically induced, as it has been suggested that ER stress inhibits the mTOR pathway. Lipid extraction methods were used to quantify ceramides and sulfatides present in immature oligodendrocytes. Results previously obtained in the lab from lipid detection suggest that direct mTOR inhibition has a negative effect on lipid levels in oligodendrocytes. Preliminary results from our experiment similarly indicate a decrease in lipid content due to ER stress. This experiment may provide insight into much needed information on the Erk1/2 MAPK and mTOR pathway and how it relates to ER stress. In addition, more can be learned about the biochemical pathways that control the biochemical changes in oligodendrocytes through the maturation process.

10.

UNDERSTANDING THE RATE OF SEGMENT ADDITION IN ARTHROPODS BY LOCATING PULSES OF MITOSES IN *TRIBOLIUM CASTANEUM* EMBRYOS

Heidi Pi '14
Faculty Sponsor: Terri A. Williams

A characteristic feature of arthropods is the presence of body segments. Arthropods add segments from a posterior region known as the growth zone. *Drosophila* has been the model system for arthropod segmentation. However, they add their segments simultaneously, while most other arthropods undergo sequential segmentation. In studying *Tribolium*, it has been discovered that the rate of segment addition is not linear. There are periods of rapid segmentation followed by periods of less segmentation. Because of this non-linear rate, we wondered what cell behaviors in the growth zone might be causing elongation. We focused our attention on locating the high levels of mitoses within the growth zone to see its relation with the rate of segment addition, and hypothesized that the timing of high mitoses rates would be prior to rapid segment addition. Previous published *Tribolium* segmentation research was successful in locating a peak of mitoses by examining the expression of the odd-skipped gene within young germ bands, and categorizing the expression into three stages. We attempted to measure mitoses levels using the complementary gene, even-skipped. The growth zones of our embryos displayed even-skipped patterning not congruent with the three aforementioned stages. Since this method proved unsuccessful, we instead counted the individual cells undergoing mitosis within the growth zone, as defined by the last even-skipped line of expression within a germ band and compared that with counts from later staged animals to create a longer time frame for comparing mitotic rates. We found that there is a pulse of mitosis prior to the 12-14 hour pulse of segment addition but no evidence of a pulse in later stages. We hypothesize that mitosis might not be necessary for the pulse of segment addition and plan to test it by blocking mitosis at 12 hour.

11.

IS ELONGATION AND SEGMENT PATTERNING INDEPENDEDNT PRCOCESSES IN NORMAL GROWTH OF A CRUSTACEAN, FAIRY SHRIMP?

Niranjana Pokharel '15
Faculty Sponsor: Terri A. Williams

Segmentation is a key feature of arthropods, the phylum with greatest number of species. In the well-known model system, fruit fly, *Drosophila* segments develop simultaneously. However, most of the arthropods develop their segments sequentially using a posterior growth zone to add segments. To understand and establish a model of sequential segmentation, we have been studying the crustacean *Thamnocephalus platyrus*. According to the most generalized model of growth zone in arthropods, cells proliferate in the posterior region of the growth zone in response to localized signals from regulatory genes, like caudal, while new segments form in the anterior region in response to other regulatory signal, like Notch signaling. Indeed, experiments show that blocking notch signaling does not affect body elongation in fairy shrimps whereas blocking caudal signaling does halt elongation while segmentation remains unaffected. These findings about Notch and Caudal suggest that elongation and segmentation are independent process. To test this hypothesis - are elongation and segmentation independent processes in fairy shrimps - we temporarily blocked cell division in fairy shrimps using hydroxyurea, a cell cycle inhibitor. We predicted that blocking cell division would slow down elongation process but that segment patterning would be unaffected. Our results show that treatment groups were similar in body length compared to the control group, animals catch up quickly once they are removed from the block instead of retaining a shorter length. In addition, treatment group had fewer segments compared to the control and segment patterning was not regular. Blocking cell proliferation in *Thamnocephalus* disrupts the normal segment formation. Our results led us to the conclusion that cell division plays important role for both segmentation and elongation and both the processes are interlinked. In future we would like to visualize where cells are dividing at the time of segment disruption in normal animals using EdU (5-ethynyl-2'-deoxyuridine) pulse chase experiments.

CHEMISTRY

12.

DISCOVERY OF A DIMERIC BY-PRODUCT IN THE PREPARATION OF A TUNGSTEN BIS-ALKYNE COMPLEX

Lauren Davidson '16
Faculty Sponsor: Timothy Curran

Forming tungsten bis-alkyne complexes involves attaching two alkynylpeptides to a tungsten center. In order to create a metallacyclicpeptide two alkynes in the same molecule are attached to the tungsten center. The alkyne component, in this work Boc-Phe-$NHCH_2CCH$, is reacted with the tungsten complex, $W(CO)_3(dmtc)_2$, under reflux. In order to analyze the products for purity, thin layer chromatography, flash chromatography, NMR spectroscopy, and mass spectrometry were utilized. In previous years, these reactions were conducted in refluxing methanol. However, reactions in methanol were yielding small amounts of the bis-alkyne product $W(dmtc)_2$(Boc-Phe-$NHCH_2CCH)_2$, or failing. This research originally sought to answer the question of whether tungsten bis-alkyne complexes could be better prepared in a solvent other than methanol, but methanol produced higher yields and purer product than toluene and chloroform. The reactions in methanol also produced an interesting and novel side product, a dipeptide (Boc-Phe-Phe-NHCH2CCH) formed from condensation of two molecules of Boc-Phe-NHCH2CCH. Formation of the dipeptide likely occurred when either one or two the Boc-Phe-NHCH2CCH molecules were coordinated to tungsten. The production of this dipeptide could explain the low yields in synthesizing tungsten metallacyclicpeptides. The structure of the dipeptide was confirmed by NMR spectroscopy and mass spectrometry, and results have been replicated in multiple reactions. Research is now directed toward probing the mechanism that creates the dipeptide, which might have applications in peptide synthesis.

13.
SURFACE CONCENTRATION OF FORMIC ACID AT THE LIQUID VAPOR INTERFACE
Jeff Pruyne ‘15
Faculty Sponsor: Maria Krisch

The liquid vapor interface has experienced renewed interest from physical chemists in last two decades as techniques to study it have become more accessible and reliable. An important property of the interface is the surface excess of a compound relative to its concentration in the bulk solution. In particular we were interested in the acidity of the interface with relation to the bulk. Excess or depleted concentration of protons at the interface could have a pronounced effect on the reactions that are favored at the interface. The surface excess can be derived from the surface tension, a measure of the intermolecular forces at the interface. In this research the surface tension of the ternary system of water, sodium chloride, and formic acid was measured with a Wilhelmy plate. It was determined that sodium chloride acted as a weak salting out agent of the formic acid. The concentration of the sodium chloride was found to have little effect on the formic acid excess, or how quickly it reached its peak concentration.

14.
SYNTHESIS AND CHARACTERIZATION OF CYCLIC TUNGSTEN BIS-ALKYNE COMPLEXES DERIVED FROM HEXAMETHYLENEDIAMINE AND m-XYLENEDIAMINE
Edgar Soto ‘15
Faculty Sponsor: Timothy Curran

In prior work this lab has demonstrated an ongoing interest in the formation of constrained tungsten-bis(alkyne) complexes (Lawrence, 2010) formed from the coordination of dialkynylamides to tungsten in an effort to generate constrained species. Because of this interest we have begun to probe the conformational rigidity of alkynes derived from diamines (via acylation of propargylchloroformate and 4-pentynoic acid with hexamethylenediamine and m-xylenediamine). The dialkynylamide derivatives of these compounds were formed using propargylchloroformate and then reacted with $W(CO)_3(dmtc)_2$ in order to form the bis(alkyne) complexes. Investigations using NMR spectroscopy have shown that the bis(alkyne) complex formed from the dialkynylamide derivative of hexamethylenediamine (via acylation with propargylchloroformate) has many conformational isomers. NMR spectroscopy experiments also indicate that the propargylchloroformate dialkyne derivative of m-xylenediamine does not form the bis(alkyne) complex. To investigate this further the results of the propargylchloroformate derived m-xylenediamine were contrasted with the 4-pentynoic acid dialkyne derivative of the m-xylenediamine. In this presentation details about this work will be discussed.

15.
CYCLIZATION OF TERMINAL DIALKYNES BY COORDINATION WITH TUNGSTEN
John Stiller ‘14
Faculty Sponsor: Timothy Curran

Three terminal dialkyne molecules were reacted with $[W(CO)_3(dmtc)_2]$ to form cyclic bis-alkyne complexes that could be studied to determine how alkyne-tungsten bond flexibility varies with dialkyne ligands. The first two dialkyne molecules were 1,9-decadiyne and 1,8-nonadiyne. Both reacted were

reacted with $[W(CO)_3(dmtc)_2]$ and ^1H NMR peaks at 11.5 suggested that bisalkyne complexes were formed. Furthermore, the presence of four siglets at 11.5 also confirmed that the product was flexible because the terminal alkyne hydrogens were rapidly rotating between different states. However, when studied under ESI MS, none of the peaks aligned with the expected mass of the bisalkyne complexes. The final molecule studied was a dialkynylamide formed by acylation of isophthalic acid with propargylamine. The dialkynylamide was formed by coupling isophthalic acid and propargylamine using the reagent PyBop in basic CH_2Cl_2.Formation of the dialkynylamide was confirmed via ^1H, ^{13}C, and COSY NMR. When reacted with $[W(CO)_3(dmtc)_2]$, the crude product showed characteristics signs of a bis-alkyne complex in the ^1H NMR spectrum, but further purification and analysis is necessary in order to confirm its formation.

ENGINEERING

16.
THE CLOGGING CASCADE OF AN ARRAY OF MICROCHANNELS
Erin Barney '15
Faculty Sponsor: Emilie Dressaire

The manipulation and filtration of dilute suspensions of microparticles are important processes for both natural and engineered systems. Relying on the comparable length scales of the microchannels and microparticles, these systems are particularly susceptible to blockage. Studies at the single-pore level have established that the clogging of a microchannel is controlled by colloidal and hydrodynamic interactions. However, clogging is a multi-scale process; the formation of single-pore level clogs often results in the blockage of a macroscopic system. The dynamics of this series of clogging events or clogging cascade are studied here. We investigate the blockage of an array of parallel microchannels and show in particular, that the rate of clog formation decreases during the clogging cascade. Through experimental measurements and theoretical analysis, we demonstrate the roles of colloidal and hydrodynamic effects in the dynamics of the clogging cascade.

17.
IGNITION STUDY OF SUPERSONIC FREE STREAM JETS USING SHOCK TUBE
Christian T. Firsching '15, Binod Giri '15, Barok Imana '16
Faculty Sponsor: John D. Mertens

A double diaphragm shock tube has been designed and built at Trinity College to investigate spontaneous ignition of fuel released from a highly pressurized vessel. A shock tube is an instrument that compresses gases to controlled, predicted high pressures, temperatures and velocities. The experimental time period inside a shock tube is very short, usually no more than a few hundred of microseconds. Therefore, one of the important aspects of this project was finding reliable mechanisms to measure the high temperature, pressure and speed of a shock wave and the gas behind it over a short length of time. This involved testing the fitting of pressure transducers into the wall of the shock tube. In addition, it required devising an appropriate optical system to measure the speed of the shock wave once it left the shock tube. Currently, the pressure transducers have been tested and used to collect data from experiments that involved inert gases and gaseous fuels. The optical system has also been built in the laboratory. Since the project requires outdoor experimenting, only one experiment has been carried out, on the athletic field of Trinity College.

18.
WAVELET BASED ALGORITHM FOR DATA COMPRESSION
Jin Feng Liu '14
Faculty Sponsor: Taikang Ning

In this paper we will present a wavelet based algorithm that compresses two-dimensional data, which are smooth in one direction and have oscillatory events in the other direction. Two-dimensional data such as hearts and seismic signals required substantial storages and transmission resources, thus data compression is advantageous to reduce these requirements. This paper is divided in three main parts. In the first one we will present the background of Wavelet transform and its application in data compression. The second part starts by describing its mathematical representation and then presents in a step by step manner the general procedure for data compression using wavelets. There are four basic steps: applying the wavelet transform, threshold detection, encoding/decoding the data and finally reconstruct the resulting data. Then this paper will conclude by analyzing the performance between our algorithm and other available data compression methods.

19.

HUMAN ARM MODEL AND PRATT TRUSS BRIDGE MODEL

Jake Mevorach '16, Hang Yang '16, Khari Jarrett '16
Faculty Sponsor: Joseph Palladino

This summer we explored a number of different areas and developed our laboratory skills through a series of brief projects. The first project was a model of the human arm. We made an arm model out of wood in the wood shop and machine shop and used it to simulate the real human arm and measured the force across it to estimate the force a real human's bicep experiences when lifting weights. We plotted the experimental data and compared to the theoretical data we plotted using MATLAB. The second project involved building a number of model Pratt Truss Bridges. Through the use of some strut kits in the lab we constructed a number of bridges under the guidance of Professor Palladino. Then we were able to attach a load and place a force transducer across constituent members of the bridge to ultimately compare real measurements we collected with theoretical predictions given to us by our professor. Efforts in both experiments were met with success and we were able to use real world measurements to corroborate theoretical predictions made about the human bicep and Pratt Truss bridges.

20.

NEW VISION SYSTEM AND NAVIGATIONAL ALGORITHM FOR AN AUTONOMOUS GROUND VEHICLE

Hokchhay Tann '14, Bicky Shakya '14, Alex Merchen '14, Abhishek Khanal '15,
Jiajia Zhao '15, Ben Williams '15
Faculty Sponsor: David J. Ahlgren

This paper presents improvements made to the intelligence algorithms and hardware employed on Q, an autonomous ground vehicle, for the 2013 Intelligent Ground Vehicle Competition (IGVC). In 2012, the IGVC committee combined the formerly separate autonomous and navigation challenges, into a single AUT-NAV challenge. In this new challenge, the vehicle is required to navigate through a grassy obstacle course and stay within the course boundaries (two white painted lines) that guide it toward a given starting GPS waypoint. Once the vehicle reaches this waypoint, it enters an open course where it is required to navigate to 8 other GPS waypoints while avoiding obstacles. After reaching the final waypoint, the vehicle is required to traverse through another obstacle course before completing the run. To accommodate for these rule changes, the software on Q had to be thoroughly revised. The modular parallel software architecture on Q which features the image processing, navigation and sensor control algorithms running concurrently, was kept the same as previous years. However, changes were made to ensure smooth switching between autonomous and GPS navigation modes at the starting and final GPS waypoints. In addition, the modified Vector Field Histogram (VFH) algorithm, employed on Q as the main navigational algorithm, suffered from poor jerking motions in previous years, due to crude motor command thresholds. The 2013 revision of Q featured a tuned VFH algorithm that allowed Q to smoothly decelerate upon encountering obstacle fields and traverse them with relative ease. A new vision system was also implemented this year. In previous years, two webcams with a small field of view and inflexible gain were used for the vision system. As a result, Q's performance for course-boundary detection varied significantly with different lighting conditions. For the 2013 competition, a Basler Scout camera with wide angle lens was used in place of the two webcams. The new camera's automatic gain and shutter speed controls enabled a consistently high level of performance. In addition, new features such as the Hough transform and color-plane multiplication were added to the image processing algorithm for better detection of the

course boundaries. Also, with the new camera, Q is able to see further down the course, allowing for better path planning. With these changes, Q was able to successfully complete the basic AUT-NAV course and finish among the top ten teams to reach the advanced AUT-NAV challenge.

ENVIRONMENTAL SCIENCE

21.
THE EFFECT OF CLEAR CUTTING ON SUB-ALPINE FOREST SOIL NUTRIENTS AND TRACE METALS WITHIN THE WHITE MOUNTAIN NATIONAL FOREST, NEW HAMPSHIRE
Justin Beslity ‘15, Daniel Hong ‘15
Faculty Sponsor: Jonathan Gourley
Non-Trinity Sponsor: Robert A. Colter, Soil scientist from USDA Forest Service, White Mountain National Forest

Clear-cutting is the most popular and economically profitable method of logging and has been in use for centuries to provide lumber. However, there are several issues with clear-cutting, which involve increased likelihood of erosions, loss of nutrients due to rapid runoff, disruption of habitats and wildlife, and the cost of aesthetic values. In the summer of 2013 with a collaboration of Andy Colter from USDA Forest Service, 266 soil samples from O-horizon and B-horizon were collected at three sites in the White Mountains National Forest: Millstone (ME), Douglas Brook (NH), and Hogsback (NH). The three sites will undergo commercial logging in the fall and will be revisited next summer to collect soil samples after the clear-cut to see the effects of clear-cutting on the soil. The purpose of this two-year study is to observe and analyze the effect of clear-cutting on soil nutrients, trace metals, nitrogen cations, toxins, and organic material and determining the sufficient baseline concentrations of the tested compounds in order for the forest to grow back over years. Milestone’s DMA-80 Direct Mercury Analyzer, ICP-OES, and loss of ignition are used to quantify the effects of clear-cutting and GIS to show the distributions of the tested compounds.

22.
MAGNETIC CHARACTERIZATION OF LAKE SEDIMENT TO RECONSTRUCT STORM FREQUENCY RECORDS IN NEW YORK
Jami Cogswell ‘16
Faculty Sponsor: Christoph Geiss

Due to erosion, layers of sediment form at the bottom of lakes. In our study area, calcareous lake sediment has low magnetic susceptibility, while the shale rock surrounding the lake has higher magnetic susceptibility. When erosion occurs, material with higher magnetic susceptibility is deposited into the lake and can be detected by its higher susceptibility values. By studying the variations in magnetic susceptibility throughout a sediment core, one can obtain information on past climatic events, such as powerful storms, that caused erosion into the lake. In an effort to study the storm history of Upstate New York, six meters of sediment core were collected from Otsego Lake in Otsego County, New York. The cores were split and continuous samples were taken from their centers. Low-field and frequency-dependent magnetic susceptibility measurements, ARM, IRM, SIRM, and back-field measurements were performed on all samples. Hysteresis loops were measured on every fifth sample, and coercivity distributions were measured on nineteen selected samples. The data suggest that the magnetic minerals in the sediment are ferrimagnetic and most likely consist of magnetite or maghemite. The grain size of these magnetic minerals is mainly in the pseudo-single-domain range with the finest material occurring from 4.9 to 8.2m and the coarsest material from 8.2 to 8.9m. The concentration of magnetic minerals in the sediment is very low, but there is a slight increase in concentration from 8.2 to 11m. No large storm layers are visible in the data collected; however, there are cyclical variations in magnetic susceptibility throughout the upper three meters of core, which may indicate periods of increased erosion.

23.
A POLLEN DIAGRAM FROM LAKE LOUISE, CENTRAL CONNECTICUT
Madeline Foley ‘14
Faculty Sponsor: Christoph Geiss

Pollen data from Lake Louise in Bloomfield, Connecticut provided information on the changing vegetation in North-Eastern America over approximately the past 22,500 years. Variations in the abundance of plant

taxa may be important indicators of climate changes that have occurred since the last glacial maximum. A pollen diagram was constructed by calculating the distribution and abundance of pollen taxa from seventy-four samples taken from various depths of Lake Louis. My pollen diagram shows a zone dominated by pine and hemlock prior to ~15,000 years before present. This is followed by a large inflow of abundant and diverse pollen species, comprised of primarily Fir, Oak, Beech, Maple and Chestnut. The new arrival of pollen species coincides with increased New England temperatures. With the exception of Pine and Oak, the majority of taxa increase slowly and steadily from ~15,000 BP until present. Interestingly, pine abundance peaked at ~ 13,500 BP and rapidly decreased afterwards, when it was replaced by an expansion of oak which has dominated until present. Ragweed pollen appeared in the past few hundred years and can be linked to the arrival of European settlers and their agricultural practices to the region. Climatic and anthropologic trends cannot explain the entirety of the pollen diagram. Further pollen analysis must be performed to arrive at a more detailed picture of Central Connecticut's vegetation and underlying climatic changes since the last deglaciation.

24.

SYNERGISM IN TOXICITY OF MIXTURES OF PHARMACEUTICALS TO *DAPHNIA MAGNA*

Airelle A. James '14
Faculty Sponsor: Alison J. Draper

Pharmaceuticals escape wastewater treatment and contaminate aquatic environments. There is increasing concern about the exposure of aquatic organisms and the combined toxicity of complex mixtures of chemicals. Four pharmaceuticals for human-use were chosen for this study. All are water-soluble, thus eliminating complications of solvent effects. All of the chosen pharmaceuticals are also commonly used and have been detected in the aquatic environment. A 48-hour motility assay of <24 hour-old *Daphnia magna* neonates was used to examine the effects of a mixture of commonly-used pharmaceuticals. LC_{50} and NOAEL concentrations of diclofenac, metformin, metoprolol and propranolol were estimated. *Daphnia* were then exposed to all possible combinations of these drugs, all at their NOAEL concentration. Synergy was observed in these mixtures. The interaction of metformin and metoprolol was also explored at concentrations around their LC_{50}'s using the classic method of mixture toxicity. Again, synergism was observed. This relationship would not be anticipated by the drugs' mechanism of action in humans. Frequent use of pharmaceuticals by consumers coupled with imperfect methods of wastewater treatment will likely increase pharmaceutical residue in the aquatic environment. Future experiments will be aimed at determining the mechanism of drug interactions observed in this study.

25.

DEGRADATION OF DISSOLVED ORGANIC MATTER BY MICROBIAL AND PHOTOCHEMICAL PROCESSES IN TEXAS RIVERS

Jessica Smith '14
Non-Trinity Sponsor: James McClelland, Marine Science Institute, University of Texas at Austin

The chemical constituents of rivers systems can greatly influence coastal estuarine ecosystems by providing nutrients or organic matter that fuel production. Dissolved organic matter (DOM) is a little explored field in Texas rivers, which can be described in part by dissolved organic carbon (DOC) and colored DOM (CDOM). The degradation of river water by light and microbial sources can indicate the fate of the matter in the estuary. Waters from the Nueces, San Antonio, and Guadalupe rivers were collected during baseflow conditions, and then were filtered. Light-exposed and dark experiments were performed in triplicate over six weeks. Treatments exposed to light were placed in a solar simulator for 24 hours. All treatments were inoculated with 1 mL of whole water. Both light-exposed and dark treatments were incubated at 24 °C in a dark cabinet. The DOC content decreased in two rivers, and in a different combination of two rivers, DOC losses were greater in light treatments than dark. Two rivers had stable S275-295 in the light-exposed treatments, while the third increased, indicating a lower average molecular weight of DOM by the end of the incubation. In dark treatments, two rivers had increasing S275-295, with little change in the third. SUVA calculations resulted in fairly stable values, higher in the dark values than the light, indicating a stable aromaticity in the rivers. The Nueces contains a reservoir creating autochthonous DOC, easier to break down and less aromatic, while the Guadalupe contains more allochthonous DOC which is recalcitrant and aromatic. The San Antonio follows the Nueces' pattern in the DOC and S275-295 results, while acting more like the Guadalupe in the SUVA results, having anthropogenic DOC sources that act differently.

These three rivers along the Texas coast show that, under normal conditions, DOM lability and quality varies greatly, owing to the diverse characteristics of the watersheds.

MATHEMATICS

26.
GENERALIZATIONS OF HYPERBOLIC TRIGONOMETRY
Greg Convertito '16
Faculty Sponsor: David Cruz-Uribe

Starting from the concept of hyperbolic trigonometry, which uses the right branch of an equilateral hyperbola $x^2 - y^2 = 1$, and a variation on Lang's idea of generalized p-trigonometry [1], we derived the generalized p-hyperbolic functions $\cosh_p$, $\sinh_p$, and $\tanh_p$ using the p-hyperbola $|x|^p - |y|^p = 1$, $p > 0$. We then found the derivatives of the p-hyperbolic functions and integral expressions for their inverses.

27.
TAXICAB GEOMETRY AND MASS TRANSIT DISTANCE
George Thekkedath '16
Faculty Sponsor: Gregory Kelsey

Taxicab geometry is a form of geometry in which one would measure distance by taking the sum of the absolute difference of the coordinates. In doing so, you can only go vertically and horizontally, which changes many things such as: distance, shapes, and the center of a figure. In this project, we explore the major differences between the taxicab metric and the Euclidean metric. Moreover, another constraint that will be explored is introducing a subway system to taxicab geometry—this is known as mass-transit distance. We will use this to get a better understanding of "midsets". A midset is a point, or a set of points that is equidistant between two points on a graph. Essentially, the objective of this research was trying to find out the relationship between the slope of the mass transit line and the slope of a specific section of the midset. After graphing numerous slopes, there seemed to be a relationship between the slope of the mass transit line and the slope of the midset but the evidence still isn't clear as to why this relationship exists.

NEUROSCIENCE

28.
INVESTIGATING THE RELATIONSHIP BETWEEN BEHAVIORAL AND ELECTROPHYSIOLOGICAL ASPECTS OF PM IN INDIVIDUALS WITH TRAUMATIC BRAIN INJURY AND HEALTHY INDIVIDUALS
Erin Aisenberg '16, Tessa Bloomquist '16
Faculty Sponsor: Sarah Raskin

Prospective memory is the ability to remember to complete a specific task at a future time. In an effort to study how traumatic brain injury affects prospective memory, two tests were performed. The first test used was the behavioral test, the Memory for Intentions Screening Test (MIST). This test combines items that require both action and verbal responses to both time and event-based cues. Throughout the test subjects were asked to simultaneously complete a word search puzzle. Subjects were asked to remember to complete the specified tasks after periods of 2 minutes, 15 minutes, and finally 24 hours. In addition, the tasks were both related and unrelated to the cue. A point value was assessed based on both the correctness of the response as well as the timing. In addition, a second electrophysiological test was also performed to assess the electrophysiological correlates of prospective memory. An electroencephalogram (EEG) was used to monitor the brain activity while the subject completed a computerized test of prospective memory. Subjects were shown word pairs and asked to categorize them as same or different. In addition, interspersed with these, they saw strings of the letters "C" and "V" in either grey or magenta. Once they saw one of these strings, from then on they were asked to hit the corresponding letter when they saw any word in that color instead of categorizing the word pair. The resulting file was then merged with the EEG file allowing each event-related potential seen to be correlated with the specific event. With the results from these two tests we hope to find a correlation between the results of the two tests and improve our

understanding of the ways prospective memory is affected by traumatic brain injury and what the underlying brain mechanisms are. A previous pilot study was conducted and the goal of the present study is to either verify those results, or if they differ, to shed new light on the affects of traumatic brain injury on prospective memory.

29.
THE EFFECTS OF CAFFEINE ON THE SYNAPTIC PLASTICITY IN THE HIPPOCAMPUS OF RODENTS

Nicholas Bellas '16, Alison Callegari '14, Yasmine Delgado '14, Julia Duggan '16, Georgia McAdams '14, Venus Nunez '14, Jenna Park '16
Faculty Sponsor: J. Harry Blaise

The Electrophysiology Laboratories at Trinity College currently uses the synapse from the perforant path to the dentate gyrus as a cellular model system to study the effects of exposure to a host of conditions, including stress, malnutrition and genetic manipulation. Over this past summer, we use the aforementioned synaptic model to study the effects of caffeine consumption on long-term synaptic efficacy which is a mechanism through which memories may be formed in the brain. Caffeine is a stimulant which is widely consumed throughout the world. However, very few studies have systematically tested the effects of caffeine on synaptic efficacy in the hippocampus of freely behaving rats. In order to conduct this research, three types of electrodes were built and surgically implanted into the brain of rodents which served as subjects for this study. These electrodes included noise-reducing ground electrodes implanted in the cortical surface, stimulating bipolar electrodes implanted in the perforant path, and monopolar recording electrodes placed in the dentate gyrus of the hippocampus. Rodents were anesthetized and placed in a stereotaxic surgical frame in order to surgically implant the electrodes into their respective brain regions. The brain signals were viewed using an oscilloscope. A week after surgery electrophysiological tests were performed and signals were recorded and analyzed. At this moment, three data points have been collected, but no significant results have been achieved.

30.
THE EFFECTS OF TWO DIFFERENT KETOGENIC DIETS, VARYING IN NUTRIENT CONSTITUTION, ON THEIR ABILITY TO ALLEVIATE AUTISTIC SYMPTOMS IN A MOUSE MODEL

Subrina Bisnauth '15, Alex Suarez '16
Faculty Sponsors: David Ruskin, Susan Masino

Autism is a neurological developmental disorder characterized by communication and social deficits as well as repetitive behaviors. The ketogenic diet (KD), a high fat, restricted carbohydrate, sufficient protein metabolic therapy, has neuroprotective properties. In particular, the ketogenic diet has been shown to significantly reduce the incidence of seizures in persons with epilepsy, a disorder that is often comorbid with autism. Additionally, a highly restrictive KD has recently been found to reverse autistic symptoms in the BTBR mouse model of autism. However, the severity of the KD is a factor in its effectiveness and clinical applicability. Here, two milder KDs with differing nutritional constituents were compared to each other and to a diet of standard rodent chow in their ability to reverse the symptoms of autism in a mouse model (BTBR). These diets were nutritionally balanced but varied slightly in the amount of many of their components, including fats, carbohydrates, minerals, and amino acids. To measure the effects of these KD's on symptoms of autism, the three-chambered sociability test and the social transmission of food preference test were conducted in BTBR mice. The first of the KDs produced a trend towards improved sociability within the three-chambered test, and significantly improved communication within the social transmission of food preference test while the other one did neither. The variability in the nutritional composition of the two tested KDs may have resulted in the differing effects of the diets. The first of the two KDs may provide insight into the metabolic process by which ketosis helps reverse the symptoms of autism. Along with this, the comparison of the two diets tested could further the understanding of what nutritional components within the KD are most effective towards reversing the symptoms of autism. Further study could be undertaken to discover how the balancing of nutrients could affect the diet's therapeutic effects.

31.
THE EFFECTS OF ALCOHOL USE ON COGNITION IN COLLEGE STUDENTS

Sharmy Dhaliwal ‘16
Faculty Sponsor: Sarah Raskin

Cognition is the mental process of gaining knowledge and understanding it through thought, experience, and the senses. This study examines the effects of alcohol use on cognition in college students by comparing their cognitive results from the beginning of their college experience to the near end of their college experience. The participants filled out numerous questionnaires regarding demographics, any injuries, and their alcohol use. Following the questionnaire, they did a series of computerized measures which tested their retrospective memories, or memory involving the past, and response inhibition. Cognitive test results from students who do not drink, those who drink but do not binge, and those who binge drink were compared. Depending on the results, methods for treating alcohol use or decreasing alcohol use on college campuses could be properly developed because the developers would know who the targeted would be and why those groups are most affected.

32.

EFFECTS OF GLIAL-DERIVED FACTORS ON APOPTOSIS IN NEUROBLASTOMA CELLS

Anne Do ‘16, Livia Wyss ‘16
Faculty Sponsor: William Church

In a double-blind study, undifferentiated SH-SY5Y cells were treated with TIMP-1 knock-out glial cell conditioned media, wild-type glial cell media, or low serum feeding media for 24 hours. Glial cells, such as astrocytes, have been shown to secrete factors that signal proliferation. Previous work from this lab found that SH-SY5Y cells treated with wild type glial cell media showed significantly increased cell death when compared to treatment with regular feeding media and TIMP-1 knock-out glial cell media. We evaluated the percentage of apoptotic cells per treatment by using the Hoescht 33342 stain, which depicts the condensed pycnotic nuclei in an apoptotic cell. There was no significant difference in the degree of apoptosis as a function of media treatment (% cell death: LSFM = 21.52 ± 1.12, TIMP-1 KO GCM = 18.71 ± 0.91, and WT GCM = 20.58 ± 1.08).

33.

METFORMIN AND A MODERATE KETOGENIC DIET: THE EFFECT ON BLOOD CHEMISTRY AND BEHAVIOR ON A MOUSE MODEL OF AUTISM

Jessica Fortin ‘14
Faculty Sponsors: Susan Masino, David Ruskin

Autism is a pervasive neurodevelopmental disorder that affects 1 in 88 people. There are limited therapies available to treat the symptoms of autism, especially because the cause of the disorder remains unclear. The ketogenic diet (KD) is a restricted carbohydrate, sufficient protein, and very high fat metabolic therapy that adjusts the body’s metabolism to use ketone bodies instead of glucose for fuel. A strict KD (76% fat) has been proven to ameliorate the core behavioral symptoms of autism, decrease glucose levels, and elevate ketones in the BTBR mouse model of autism. In contrast, a moderate KD (66% fat) was proven ineffective in the BTBR model and did not decrease glucose levels, although ketone levels were increased. The metabolic mechanism behind the diet remains elusive, with lowered blood glucose cited as a possible key component of its efficacy. Metformin is the most commonly prescribed medication to treat hyperglycemia in patients with Type 2 diabetes and is believed to lower or stabilize blood glucose by inhibiting gluconeogenesis in the liver, activating AMPK glucose reuptake in muscle, and decreasing cyclic AMP production. Our goal was to use metformin in conjunction with a moderate KD to determine whether a greater decrease in or stabilization of blood glucose along with elevated levels of ketones is sufficient to ameliorate the symptoms of autism in the BTBR mouse model. BTBR mice were fed either a control diet with 300mg/kg metformin dissolved in water, a moderate KD with metformin, or a moderate KD with water alone for three weeks. At 8 weeks of age the mice underwent behavioral testing to analyze sociability, communication, and self-repetitive behaviors. Weight and blood chemistry data were taken before dietary treatment and after behavioral testing. No significant differences in blood chemistry or behavior were noted between KD and KD+metformin treatment groups. Metformin may not have been the most effective means of lowering blood glucose: this study was unable to address the relationship between lower glucose levels and the efficacy of the KD.

34.

THE EFFECT OF THE KETOGENIC DIET ON THE POLY (I:C) MOUSE MODEL OF AUTISM

Michelle Murphy ‘14
Faculty Sponsors: Susan Masino, David Ruskin

Autism is a neurological disorder that is characterized by the core symptoms of impairments in sociability and communication, as well as, restricted and repetitive behavior. The ketogenic diet (KD), a restricted carbohydrate, sufficient protein, and high fat metabolic therapy, has been found to reverse the core symptoms of autism in the BTBR mouse model. The core symptoms of autism are also seen in the poly (I:C) mouse model, which was developed based on epidemiological observations that an immune challenge during pregnancy increases the risk of autism in offspring. Poly (I:C) is a synthetic analog of double stranded RNA that acts as a viral mimic to induce an immune response, but not an active infection. When a pregnant mouse is exposed to poly (I:C), it causes maternal immune activation (MIA), which results in the offspring demonstrating the core symptoms of autism. This study will investigate the effect of a strict KD on the autistic symptoms of the poly (I:C) mouse model of autism. Timed pregnancies were determined by the presence of a vaginal plug (day 0.5 of gestation) and the pregnant mouse was then injected with 5mg/kg of either saline or poly (I:C) on days 10.5, 12.5, and 14.5 of gestation. The offspring will be organized into three groups: saline offspring fed control diet, poly (I:C) offspring fed control diet, and poly (I:C) offspring fed KD. Behavioral testing will be conducted using the 3-chamber sociability test, the STFP (social transmission of food preference) test, and self-grooming test. The results of this study will contribute to understanding the role of the ketogenic diet in alleviating autistic symptoms.

35.

SUPPLEMENTATION OF THE KETOGENIC DIET WITH EVEN- AND ODD-NUMBERED MEDIUM CHAIN TRIGLYCERIDES IN A MOUSE MODEL OF AUTISM

Lisa Saa ‘14
Faculty Sponsors: Susan Masino, David Ruskin

A ketogenic diet (KD), which has restricted carbohydrates, sufficient protein, and a very high fat content, causes the body to switch from a glucose-based metabolism to a ketone-based metabolism. The KD has been effective at reducing seizures in epileptic patients. Autism is comorbid with epilepsy and characterized by restricted and repetitive behaviors, low sociability, and deficits in communication. A strict version of the KD has been effective at reducing autistic symptoms in BTBR T+tf/J, an autistic model of mice. However, a more moderate and clinically relevant version of the KD has been shown to be ineffective in this model. Furthermore, the mechanism of the KD is unclear. Recent studies suggest that supplementation of the moderate KD with medium chain triglycerides (MCTs) will reduce the severity of autistic symptoms. MCTs are fatty acids with carbon chains ranging from approximately 7 to 12 carbons. They are usually in the form of oils or soft solids at room temperature. Natural sources of MCTs include butter and coconuts. MCTs may cause an increase in ketone bodies, acetyl-CoA, and ATP. However, only odd-numbered MCTs are anaplerotic substances, meaning that the metabolites of the Krebs cycle are refilled. The goal of the study is to determine a) the role of anaplerosis on ketosis and the KD and b) if either even- or odd-numbered MCTs alone or supplementing a less strict KD can result in a beneficial alleviation of autistic symptoms in mice. To test this hypothesis, BTBR T+tf/J mice will be given one of the following metabolic treatments for three weeks: chow (control), KD, chow and odd-numbered MCTs, KD and odd-numbered MCTs, chow and even-numbered MCTs, or KD and even-numbered MCTs. Behavioral testing and glucose and ketone blood analysis will be conducted. The results may help elucidate the mechanism of the KD and offer clinical relevance. The study will be the focus of a senior thesis.

PHYSICS

36.

STUDY OF ULTRAFAST DYNAMICS IN NANOSCALE

Pratistha Shakya ‘15
Faculty Sponsor: Brett Barwick

An ultrafast electron microscope (UEM) can be used to follow dynamics on the nanoscale by combining the high spatial resolution of an electron microscope with temporal resolution of a femtosecond laser. This is done by first exciting the specimen with a femtosecond laser pulse and then imaging the same specimen at a well-defined time delay with an electron pulse. By varying the delay between the 'pump' laser pulse and the 'probe' electron pulse a movie can be made of the ultrafast dynamics. In our lab, we are developing a novel ultrafast electron point projection microscope that combines a simple point projection electron microscope with a femtosecond electron tip source. Through modeling, we can show that our UEM in principle can reach a higher temporal resolution compared to a UEM based on a conventional design. We also present recent imaging results demonstrating the microscopes ability to image in femtosecond electron pulsed mode with resolutions better than 100 nm, while simultaneously doing electron spectroscopy on a specimen.