College of Natural Sciences and Mathematics

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Does Early Exposure to Pain Alter Brain Function?
Brian Bowden, Julie Carter, Jason Fechter, Danny Glassman, Amanda Plummer, Debbie Soellner, Kate Street, and John Frank
Faculty Mentor: Barbara Clancy

Distribution and Connectivity Patterns of Persisting Cortical Subplate Cells in Aging Swiss Webster Mice
Jason Fechter, Bowman, B., Hyde, J., Isbell, S., Palmer, S. and Seballos, P.
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Acidification induced exocytic response in MCF-7 cells and correlating apoptosis
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Faculty Mentor: Steve Runge

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Proximate cue or ultimate cause: Why does myristicin trigger trenching?
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Physics and Astronomy

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ABSTRACTS

BIOLOGY

Does Early Exposure to Pain Alter Brain Function?

Brian Bowden, Julie Carter, Jason Fechter, Danny Glassman,
Amanda Plummer, Debbie Soellner, Kate Street, and John Frank
Faculty Mentor: Barbara Clancy

Children born prematurely often have long-term cognitive and behavioral problems, indicating a disruption in brain function. It is suspected that these problems are associated not with premature birth itself, but with the pain experienced during lifesaving and routine procedures, which are often performed without anesthesia. We hypothesize that when neonatal mammals are exposed to pain without anesthesia, the structure of the brain itself is altered, a disruption that can be minimized if anesthesia is administered for an appropriate time-period. The overall goal of this study is to better understand how pain and/or anesthesia in newborns might affect the way the brain develops, with a focus on an area of the brain called the cortex. Previous research indicates rats exposed to neonatal pain develop problems similar to those experienced by ex-preterm humans. We are analyzing 1) the behavior of rats that have undergone painful neonatal experiences with and without anesthetic drugs and 2) the brain of the same animals including the structure of the cortex in treated and control animal groups. Using these data, we will begin to understand how brain disruption may be associated with developmental disorders often seen in children who were born prematurely.

Distribution and Connectivity Patterns of Persisting Cortical Subplate Cells in Aging Swiss Webster Mice

Jason Fechter, Bowman, B., Hyde, J., Isbell, S., Palmer, S., and Seballos, P.
Faculty Mentor: Barbara Clancy

The mammalian cortex is a thin layer of neurons that covers the exterior of the brain and matures above the subplate. Subplate neurons are typically identified by their characteristic position subjacent to the cortex, morphological and labeling patterns, and early cell death. Subplate neurons play an important role in cortical development, but little is known about a subset that persists through maturation. We labeled subplate cells in a mouse model (Swiss Webster) using retrograde fluorescent tracer deposits in motor, somatosensory, and visual cortices, including deposits restricted to cortical layer I. Our data suggest that the distribution and connectivity patterns of persisting subplate cells remain stable across normal adulthood (6 wks ˆ 20 mos), although patterns vary slightly based on cortical location. Advanced aging (>18 mos) may reduce labeling of subplate cells, but whether this is due to altered connectivity, reduced cell numbers, or reduced subplate function remains to be studied.

Acidification induced exocytic response in MCF-7 cells and correlating apoptosis

U.B. Haley
Faculty Mentor: Steve Runge

The interior of solid tumors has poor vascularization resulting in an extracellular environment with a pH below normal. This low pH is due principally to the build up of metabolic waste. An acidic extracellular environment can instigate the build up of intracellular H^+ that can induce apoptosis. Cell survival in this environment requires the use of additional pH regulatory mechanisms to prevent apoptosis. A growing number of studies have revealed vesicular trafficking as a method of regulating the activity of transporters in the cell membrane.

Our research indicates that intra- and extracellular acidification stimulates vesicular trafficking in cultured human breast cancer (MCF-7) cells. Potential roles of microtubules and actin-filaments in stimulated vesicular trafficking and the correlation between apoptosis and ability to exocytose will be investigated.

Role of Pedal Three Neuron in turning of *Tritonia diomedea*

Joshua Morrison
Faculty Mentor: James Murray

Our research focuses on the sea slug *Tritonia diomedea*. Specifically, we will study the Pedal (Pd) 3 neuron. This neuron is responsible for foot movement of the animal. Firing of Pd 3 causes the animal to contract its foot. We will use microelectrodes and intracellular recording techniques to study Pd 3. We will stimulate the foot with variable currents in order to elicit a response. We will use video camcorders to capture the animals' movement of the foot. By comparing the video with our electrophysiology data, we will be able to determine velocity of foot movement, area of foot moved, and time to rest. Knowing this will allow us to see how Pd 3 interacts with other neurons in performing natural behaviors such as turning towards the direction of water flow, approaching prey, and escaping predators.

Proximate cue or ultimate cause: Why does myristicin trigger trenching?

Ken Pigue
Faculty Mentor: David Dussourd

Caterpillars of the cabbage looper, *Trichoplusia ni*, often cut trenches across leaves, thereby deactivating defensive canals and reducing larval exposure to plant exudates such as latex or resin. Previous work has identified myristicin, a phenylpropanoid found in parsley, as a chemical elicitor of trenching. We sought to test if myristicin is poisonous for cabbage loopers. If so, trenching could function specifically to reduce larval exposure to myristicin. Our approach is to inject 2 μl of water or myristicin into the guts of narcotized loopers. We will record the time until loopers resume feeding, pupal weight, and survival to adult stage. Initial results suggest that loopers require longer to recover after receiving myristicin. This study is the first to test the toxicity of a chemical stimulant of trenching.

Predicting the timing of neural and visual development across mammalian and non-mammalian species

Julie Staudinger, Danny Glassmann, and Jessica Harrison
Faculty Mentor: Barbara Clancy

A mathematical model originally derived to study evolutionary change in the developing mammalian nervous system has also proved useful in predicting the timing of neural development, including the development of human infants (Clancy et. al, 2001 Neuroscience 105: 7-17). The model predicts aspects of neurogenesis and axonal outgrowth in the brains of developing mice, hamsters, rats, spiny mice, rabbits, ferrets, cats, monkeys, and humans. In this study, two new species are added, guinea pigs and chickens. The guinea pig is added because this species is precocial and it should prove useful to test the neural model in a mammalian species born at such an advanced somatic stage. Chickens are included for two reasons: 1) to test the model in a non-mammalian species and 2) because a wealth of visual development is available for developing chicks, a great deal of visual data might thus be successfully “translated’ to human development. We will relate the timing of neural and visual events across the eleven species in the form of a reference table that will be made accessible on an interactive website.

Identification of the regulatory proteins controlling intracellular pH in cultured human breast cancer cells

Brandon Walser and Dana Strassle
Faculty Mentor: Steven W. Runge

Apoptosis, or programmed cell death, is an essential mechanism for the development and maintenance of multi-cellular organisms. Intracellular acidification is an event that occurs in many cell types during apoptosis, and acidifying the intracellular environment is sufficient to induce apoptosis. Cancer cells are unique relative to non-cancerous cells in that, while they maintain intracellular pH at near physiologic levels, they are surrounded by highly acidic extracellular fluid. One mechanism whereby they might increase their ability to regulate intracellular pH may involve cytoskeletal-based trafficking of pH regulating proteins to and from the plasma membrane. The Na+/H+ exchanger (NHE), the Na+Cl-/HCO3- exchanger (NCBE), the vacuolar proton ATP-ase (VP-ATPase) pump and the monocarboxylate transporter (MCT) are candidate proteins that will be investigated. This research will identify the protein or combination of proteins responsible for the regulation of intracellular pH in cultured MCF-7 human breast cancer cells. In this study, MCF-7 human breast cancer cells will be placed on a confocal microscope, transiently acidified, and allowed to re-alkalinize in the presence or absence of drugs that specifically inhibit individual pH regulatory proteins. Changes in intracellular pH will then be monitored to determine the effect that inhibition of individual proteins have on the recovery of the cells from an intracellular acidification Thus far, the microscope has been calibrated by creating a standard curve from which pH changes will be interpolated from changes in fluorescence ratios. . We have begun to individually inhibit specific pH regulatory proteins, and plan to also investigate the inhibition of different combinations of these proteins. If intracellular pH is not restored to normal physiological pH (7.2-7.4) after acidification and drug treatment, it will be strongly suggested that the inhibited protein does contribute to the regulation of intracellular pH during recovery from intracellular acidification in these cells.

Increased habitat heterogeneity: effects on macroinvertebrate biomass and distribution patterns in a shallow eutrophic reservoir

Bradley S. Williams
Faculty Mentor: Joseph Shostell (Penn State Fayette)

We determined the effects of cypress trees on benthic macroinvertebrates in Lake Conway (Conway, Arkansas), the largest man made Game and Fish Commission lake in the United States. Abundance, biomass, diversity, and evenness of macroinvertebrates were calculated from benthic samples collected at 0, 3, 6, and 20 meters from cypress trees. The benthic community was dominated by *Chaoborus*, chironomids, and oligochaetes and had a low mean biomass (213 mg m-2) and abundance (300 individuals m-2), which may suggest high predation, pollution, or low oxygen concentrations. However, biomass ($P < 0.001$), abundance ($P = 0.018$) evenness ($P = 0.005$) and diversity ($P = 0.001$) of macroinvertebrates were significantly greater in benthic areas closer to cypress trees. Cypress trees may be key factors that increase heterogeneity and strongly influence the benthic macroinvertebrate community by providing nutrients, sediment stability, refuge from predators, oxygen, and increased niche space.

CHEMISTRY

Chemical Switches: State-Specificity in the Gas Phase Reactions of Cu^+, Ag^+, and Au^+ with Halogenated Methanes

Cullen C. Matthews and Kristin S. Parkhill
Faculty Mentor: William S. Taylor

Numerous studies have illustrated that the outcomes of reactions of bare transition metal ions can be dramatically influenced by the electronic state of the metal -often to the extent that certain states become unreactive regardless of favorable energetics for a given product channel. A frequently-cited goal of research into transition metal ion chemistry is somehow to exploit this sensitivity in order to control product formation. Research focusing primarily on first-row ions has illustrated that state-specificity can be successfully rationalized within the framework of conservation of electron spin; however significant spin-orbit coupling in second- and third-row ions makes the exclusive use of spin as a predictive tool less certain. Indeed, comparatively few studies have been reported in which the spin states of heavy ions have been definitively specified. Previous studies by other researchers have reported that Au^+ participates in sigma bond activation in halomethanes, but the electronic state specificity has not been ascertained. We have previously examined the reactions of Au^+ and Cu^+ in both the ^1S ground state and the ^3D first excited state with CH_3Br in which the outcomes are consistent with both the known thermochemistry and overall conservation of spin. In the work described here, the reactions of $(^1S,^3D)Cu^+$ $(^1S)Ag^+$ and $(^1S,^3D)Au^+$ with CH_3Cl, CH_2ClF, $CHClF_2$ and CF_3Cl. Our objectives are to evaluate differences in product formation from the two states for each metal, and to assess the applicability of the spin-rule with respect to the behavior of Ag^+ and Au^+.

COMPUTER SCIENCE

Computational Study of a Wire Tension Problem at Tokusen USA

Sze-Huan Chin
Faculty Mentor: Chenyi Hu

In this project, we study and analyze the behavior of a wire path on a wire bunchier machine at Tokusen USA Inc. The function of the machine is to joint two wires together.

When the binding process begins, two wires from different rods at the same side are combining together through rotating exercise. The binding wire behaves like a jump rope with two fixed points at each side of the machine. We are looking for the mathematical model and computational methods of the wire path in this specific application problem. By analyzing the tension of the wire and other conditions, we established a model of nonlinear ordinary differential equation with Dirichlet boundary condition. Then, we solve it computationally with shooting and collocation methods. We found reasonable numerical approximations for the problem.

Automated Robot Guidance through Sonar Navigation and Color Recognition

Chad Miller, Josh Hight and Justin Michaels
Faculty Mentor: Han-Chieh Wei

Our preliminary research into robotics focused upon creating an application that utilizes the robot's existing sonar and contact sensors in correlation with the vision sensor we installed in order to produce a system capable of identifying an object while navigating an environment. The system created should be able to be introduced into a zero-knowledge environment, avoid obstructions visible to its sonar ring, and through its vision sensor identify the object for which we are searching.

For simplicity, the object we chose for the vision sensor testing was a plush purple monkey. The stark contrast of colors between the monkey and the surrounding environment aids in our detection of the object. Once a certain percentage of the desired color range is viewed within the image, the Intelligent Image Processing class will split the image into multiple sections and use the section with the highest percentage of the color to determine a modification for the course to guide the robot to the object. Once the object is close enough, our masking algorithms will compare the current image with several 'masks' of the object for which we are searching and determine whether this is a valid object or not.

We will expand the robot's system by implementing a wireless, multi-purpose Artificial Intelligent engine that will allow multiple robots to have simultaneous connectivity to a single Artificial Intelligent System.

Improving Efficiency for Latent Semantic Indexing of Large Dynamic Document Collections

Benjamin Severs
Faculty Mentor: Chenyi Hu

Latent Semantic Indexing (LSI) is a process that used to index document collections by topic as an addition to keyword or other method. It can also be used to perform a query on a collection of documents to find the documents that are most relevant to the query based on topic. In dealing with large dynamic document collections, LSI can be very time consuming. In this project, we report our investigation on how to reduce the time and computational costs associated with performing LSI on a large dataset by segmenting the dataset into smaller subsets within tolerable accuracy difference.

MATHEMATICS

Parametric Symmetries of Ordinary Differential Equations

Yousuf Abbasi
Faculty Mentor: Danny Arrigo

The method of symmetry analysis of ordinary differential equations (ODEs) was first introduced by Sophus Lie in 1881 as a method to unify the seemingly unrelated techniques in solving ODEs. It is well known that if a nonlinear second order ODE admits an 8-parameter Lie group of symmetries, it can be transformed into a linear second order ODE.

If the ODE fails to admit an 8-parameter family of symmetries, it is still sometimes possible to linearize the equation. We will show that if both independent and dependent variables in the equation are parametrized, a second equation can be chosen (for completeness) as the new system admits an 8-parameter family of symmetries, thereby indicating linearization.

Symmetry Analysis of the One-Dimensional Heat Equation with Variable Diffusivity

Joel Harris
Faculty Mentor: Danny Arrigo

Symmetry methods can typically be used to find exact solutions to complicated partial differential equations. While there are standard methods for solving the one-dimensional heat equation without a source term and with constant diffusivity, the problem becomes much more complicated when one or both of these are included. Previous work involved a change of variables from a heat equation of the form $u_t = D(x)u_{xx}$ (diffusivity varies with respect to the horizontal axis) to one of constant diffusion with a source term *i.e.* $u_t = u_{xx} + f(x)u$ and deriving classes of diffusion where $f(x) = 0$. The goal of this research is to use symmetry methods to deduce further classes ($f(x) \neq 0$) of solvable diffusion equations with variable diffusion.

Multigrid Numerical Solver

Garth Johnson
Faculty Mentor: Irene Livshits

The purpose of this project is to develop a multigrid numerical solver for linear elliptic equations. I developed a multigrid V cycle that uses two multigrid schemes, Correction Scheme and Full Approximation Scheme. The solver also uses the numerical techniques of cubic interpolation, full weighting, and Gauss Seidel Relaxation. I tested the solver for the model boundary value problem and obtained high convergence rates and second order accuracy of the solution.

PHYSICS AND ASTRONOMY

Spectroscopic Observations of a Nova Outburst and Be Stars

Bart Dunlap
Faculty Mentor: Scott Austin

Spectroscopic data on Be stars and a nova in outburst were obtained using the UCA Observatory's 11-inch telescope and fiber-fed spectrograph. Between September 2003 and January 2004, the spectra of approximately 25 Be stars were observed using the spectrograph's high resolution diffraction grating (0.8 Å/pixel). Spectra of V475 Sct (Nova Scuti 2003) were obtained at low resolution (5 Å/pixel). In both cases, H_ was observed. The Be spectra provide information on the disk of gas that surrounds the B-type star and causes spectral emission features. The nova spectra, obtained early in outburst, help to characterize the rapidly expanding shell blown off during the explosion.

Particle Induced x-ray emission experiments (PIXE) to determine sample elemental composition and unknown sample thicknesses

C. Eric Easton and Chris A. McNeill
*Faculty Mentors: Rahul Mehta and Stephen R. Addison**

In this experiment a Van de Graff accelerator was used to create an ion beam of protons at energy level of 1.5 MeV that was collided with target samples of elements in a scattering chamber. The particle beam knocked electrons out of their occupied energy shells and as higher energy shell electrons fell in to replace those knocked out, energy was released in the form of x-rays. The x-rays were detected and analyzed for their energy level, which was then compared to known x-ray energies thus allowing for the identification of the target elements. The change in x-ray energy from two samples (one of known thickness and one of unknown thickness) of the same element can be used to determine the thickness of unknown sample. (*We also acknowledge the assistance of Dr. Jerome L. Duggan and Dr. Fabian Naab of the University of North Texas.)

Rutherford and Non-Rutherford Scattering of 1.5 MeV Protons by $_{28}$Ni, $_{6}$C, and $_{8}$O Targets

Jason House and Bart Dunlap
*Faculty Mentors: Rahul Mehta and Stephen R. Addison**

Scattering behavior of protons incident on $_{28}$Ni, $_{6}$C, and $_{8}$O targets is experimentally investigated. A Van de Graaff accelerator is used to accelerate protons to 1.5 MeV. After colliding with the target, they are deflected at various angles, where a particle detector measures the yield of scattered protons per number of incident protons. These measurements are compared with those resulting from theoretical Rutherford scattering calculations. It is observed that at high angles, the scattering from $_{6}$C and $_{8}$O targets exhibits non-Rutherford behavior while $_{28}$Ni displays Rutherford scattering at all angles. (*We also acknowledge the assistance of Dr. Jerome L. Duggan and Dr. Fabian Naab of the University of North Texas.)

Acoustic Properties of Porous Materials

Chris McNeill
Faculty Mentor: Carl Frederickson

The porous properties of materials are important in outdoor sound propagation, noise suppression and other areas of interest. Controlled laboratory measurements of the porous properties of powder like glass beads have been made using acoustical means. The characteristic acoustic impedance and the acoustic propagation constant of unconsolidated glass beads can be determined from acoustical measurements made from an impedance tube. Models for the acoustic properties of porous materials are used to determine the porous properties of the glass beads. Future research will include making non-acoustic measurements of flow resistively on the same samples that are used in the impedance tube in order to compare the acoustic and non-acoustic determination of porous properties.

Kinematics in Rutherford Scattering

Scott Sullivan and Angela Roper
*Faculty Mentors: Rahul Mehta and Stephen R. Addison**

Particle scattering was investigated for energetic alpha particles on different element sample targets originating from a 2.5 MeV Van de Graff accelerator at the University of North Texas. A variable magnetic field allowed the selection of the alpha beam article initial energies to be 1.25 MeV and 1.50 MeV. The energetic incident alpha particles struck the element targets and scattered. These scattered particle energies were detected and measured at an angle of 150^{o}. We formed a ratio between the incident beam energy and the scattered particle energy and compared it with the values calculated from the theoretical kinematical scattering factor. The theoretical kinematical scattering factor was derived by applying the conservation of energy and the conservation of momentum to ion-atom collision. (*We also acknowledge the assistance of Dr. Jerome L. Duggan and Dr. Fabian Naab of the University of North Texas.)