Khadija

College of Natural Sciences and Mathematics

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Temporal Relationship Between Intracellular Acidification and Caspases During Apoptosis in C3H-10T1/2 Cells

Dena Cantrell
Faculty Mentor – Steven W. Runge

Among the host of biochemical activities involved in the progression of apoptosis are the activation of proteases called caspases and a sustained intracellular acidification, both of which occur late in the biochemical pathway of apoptosis. Upon activation, caspases cleave multiple proteins, and cleavage of the nuclear protein PARP is indicative of caspase activity. Intracellular acidification can induce apoptosis in cultured animal cells, but its mechanism of action remains unknown. This project is designed to determine whether intracellular acidification stimulates apoptosis by direct stimulation of caspases or at a point downstream from where caspases are activated.

The experiments use C3H-10T1/2 cells expressing the anti-apoptotic protein P35. P35 functions as a caspase inhibitor. Cells will be stimulated to undergo apoptosis by either serum withdrawal (an upstream stimulus) or intracellular acidification. We have shown previously that the P35 expressing cells are resistant to serum withdrawal, but sensitive to intracellular acidification, whereas non-P35 expressing cells are sensitive to both stimuli. Western blot analysis will be used to quantify the degree of PARP cleavage at 6 hour intervals after stimulus. The detection of intact PARP will indicate little or no caspase activity. If caspases are activated, two low molecular weight PARP bands will be observed. Our hypothesis predicts that no PARP cleavage will occur in any cell type upon intracellular acidification, indicating that intracellular acidification acts after caspase activation. The detection of PARP cleavage in any of the acidified cells would suggest that acidification is directly activating the caspases, even in the presence of P35.

Apoptosis in C3H-10T1/2 Cells: Evidence for pH Threshold for Apoptotic Induction

Alexandra A. Ebie
Faculty Mentor – Steven W. Runge

Intracellular acidification is emerging as an important phenomenon in the progression of apoptosis. In an effort to confirm the order of apoptotic events relative to intracellular acidification in C3H-10T1/2 cells, we have evaluated cells both expressing and not expressing the caspase-inhibitor P35 for susceptibility to apoptotic induction. Untransfected cells, p35-transfected cells, and vector transfected cells were serum withdrawn and subjected to intracellular acidification. Intracellular acidification is achieved by transferring cells to culture medium at pH levels from 6.2 to 6.9 containing the proton ionophore carbonyl cyanide m-chlorophenyl hydrazone (CCCP). This

treatment effectively clamps the intracellular pH of the cells at the extracellular pH. While P35 significantly delayed apoptosis induced by serum withdrawal, intracellular acidification induced apoptosis independent of the presence of P35. While confirming the mode of cell death at 24 hours of acidified cells by Annexin V/propidium iodide staining and fluorescent microscopy, cells at pH 6.5 and above were apoptotic whereas cells clamped below 6.5 appeared necrotic. However, at 1 hour post-clamping, all dying cells were apoptotic. Taken together, these results indicate that intracellular acidification triggers apoptosis at a step downstream from caspase activation and that acidification below the 6.5 pH threshold induces apoptosis very rapidly with an accelerated onset of secondary necrosis.

Habitat Partitioning in a Lotic Crayfish Community in the Ozark Plateaus: The Role of Environmental Variables

Camille Flinders
Faculty Mentor – Dan Magoulick

The importance of physical characteristics in determining crayfish community structure in the Ozark Plateau region was examined at two sites each on the Warm Fork River, Missouri and Jane's Creek, Arkansas. Twenty replicate quadrat samples were collected from six macrohabitat types (riffle, run, pool, stream margin, vegetated areas, and backwater) at each site and the physical characteristics from each sample were quantified. Ordination analyses indicated that measured environmental variables were responsible for a significant amount of spatial variation in crayfish density. At all sites, vegetation was the most important factor in explaining differential crayfish density with significantly greater number of crayfish occurring in vegetated areas. Crayfish were also significantly negatively associated with depth, current velocity, and silt substrates. The four crayfish species collected during the study differed in relative abundance and habitat use among the sites. *Cambarus hubbsi* and *Orconectes punctimanus* were significantly more abundant in the Warm Fork than in Jane's Creek with *C. hubbsi* found primarily in the faster riffles and runs and *O. punctimanus* in vegetated habitats. Densities of *Orconectes marchandi* were similar in both streams showing a significant correlation with pool and stream margin habitats in the Warm Fork and with stream margin and vegetated macrohabitats in Jane's Creek. *Orconectes ozarkae* was less abundant in the Warm Fork than in Jane's creek and positively correlated with vegetation in both streams. These data indicate habitat partitioning within lotic crayfish communities and demonstrate the importance of environmental characteristics in driving crayfish habitat selection.

Measurement of the Neuronal Activity in the Rat Basal Ganglia Following Long-Term Treatment with Two Types of Antidepressant Drugs May Offer Insight into the Treatment of Psychiatric Disorders

Jason C. Granger[1], Lolita Palmer[2], and Jay A. Vacca[3]
Faculty Mentor – Deborah Kreiss[2]

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This research study intends to investigate the effects on the brain of two drugs commonly used in the treatment of psychiatric disorders: desipramine (i.e. Norpramine) and fluvoxamine (i.e. Luvox). Although there have been many studies involving examination of the effects of psycho-therapeutic drugs in areas of the brain dealing with emotions and moods, there have been relatively few studies of the effects of such drugs on areas of the brain related to movement, such as the basal ganglia. Research of the effects of desipramine and fluvoxamine on the basal ganglia could improve treatment of psychiatric patients who have been co-diagnosed with a movement disorder (e.g. Parkinson's disease), as well as improve treatment of patients with disease states involving both cognitive and movement dysfunction (e.g. Tourette's syndrome).

It is known that short-term treatment with desipramine and fluvoxamine affect neurotransmission by enhancing and prolonging the effects of neurotransmitters in the brain. However, the mechanisms by which these drugs exert their therapeutic effects are unknown since the psychiatric symptoms are not alleviated by short-term treatment, but by long-term treatment (i.e. several weeks). The effects of both short-term and long-term treatment with desipramine and fluvoxamine on the basal ganglia was examined in rats using two approaches. One approach involved measurement of the spontaneous electrical activity of neurons of the basal ganglia (specifically, the substantia nigra pars reticulata and pars compacta). The other approach involved measurement of the electrical response of substantia nigra neurons to a drug (mCPP) which is hypothesized to reflect decreased basal ganglia output: chewing mouth movements. Preliminary studies indicate that although long-term treatment with desipramine and fluvoxamine had different effects upon the behavioral response to mCPP (see Varghese *et al.*, 1999), neither the spontaneous activity nor the response to mCPP in the substantia nigra were altered.

Snail Gut Epithelium as a Model for Apoptosis

D. DeLynn Holleman
Faculty Mentor – Steven W. Runge

A viable invertebrate alternative to the mammalian models now in use for the study of intestinal apoptosis and cytotoxicity may be introduced if apoptotic induction rates and locations in Aplysia californica intestinal crypts are similar to those observed in Sprague-Dawley rats. By exposing the Aplysia and rat gut tissues to intracellular acidification and to drugs known to inhibit or promote apoptosis, we are able to compare apoptotic induction in the gut tissues of the two species. The apoptotic indices in the gut tissues of Aplysia and rats are being determined by manual counting of apoptotic cells on hematoxylin and eosin stained cross sections using light microscopy. Apoptosis will be confirmed using fluorescent microscopy. Preliminary results indicate changes in apoptotic rates along the length of the Aplysia intestine, and initial intracellular acidification and drug treatments show that the intestinal tissues of the two species appear to respond similarly to cell lines previously studied. A similar response in the tissues of these two species to these treatments may lead to the development of a new invertebrate animal model for the study of intestinal cancers and drug sensitivities.

Role of jun-N- Terminal Kinases in Acidification Induced Apoptosis

Kelly C. Johnson
Faculty Mentor – Steven W. Runge

Apoptosis is a type of cell death that is programmed by the nucleus. Intracellular acidification can induce apoptosis. The physiological pH in mammalian cells is approximately 7.4 and a pH below 6.8 is considered to be acidified. We have shown previously that cells subjected to an intracellular pH below 6.4 have a faster rate of induction compared to cells subjected to a pH between 6.4- 6.8. The jun -N -terminal kinases are a group of kinases activated during cellular stresses. Two cell lines, C3H 10T1/2 , a mouse fibroblast cell line, and MDA-MB 468, a breast cancer cell line, will be monitored for JNK activity using intracellular pH levels of 6.25, 6.75, and 7.25. A decrease in intracellular pH has been shown to activate JNK, and we will assess the role of JNK in acid- induced apoptosis by transfecting both the JNK1 gene and its dominant negative mutant form (JNK-APF) into both cell lines. Apoptotic induction will be assessed by cell counting, DNA fragmentation, PARP cleavage , and annexin V staining. We will also determine if the nucleus is downstream of JNK1. Enucleation of the four cell lines: C3H 10 T 1/2 (JNK), C3H 10 T 1/2 (JNK-APF), MDA-MB 468 (JNK), and MDA-MB 468 (JNK-APF) will be done. An alternative method to assessing nuclear involvement will involve the use of a dominant negative mutant of the transcriptional activator AP-1, a known target for JNK1.

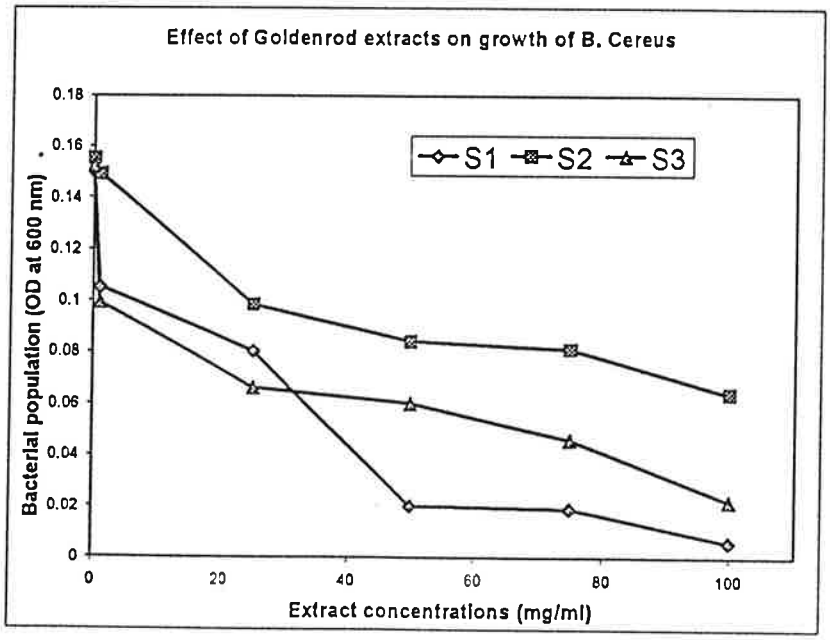
Comparative Screening of Arkansas Solidago Species for Anti-microbial Activities Using Modern Bioassays Methods

Ash Kaushesh
Faculty Mentor – John Choinski

Three related Goldenrod species: *Solidago canadensis L.* (S1) (Canada Goldenrod), *Solidago ulmifolia* (S2) (Elm Leaf Goldenrod), and an outgroup *Euthamia leptocephala* (S3) (also known as *Solidago leptocephala*, *Solidago graminifolia*, and *E. camporum*), were tested for anti-microbial activity against the pathogens: *Bacillus cereus (BC)*, *Staphylococcus aereus* (SA), *Dermatophilus congolensis* (DC), *Mycobacterium smegmatis* (MS), *Escherichia coli* (EC), *Salmonella choleraesuis* (SC), and *Candida albicans* (CA) using agar diffusion (qualitative), tube dilution (quantitative) and brine shrimp toxicity assays. The plants were collected at three different locations, and each collection was tested at least three times. Commonly used antimicrobial controls were used to show relative activity.

All three crude extracts inhibited growth of *BC*, *SA* and *DC* with inhibition diameters in the range of 20-26mm; *MS* in the range of 22-30mm, and in one case *CA* with a diameter of 15mm. It was seen that *Solidago sp.* crude extracts showed relatively similar antimicrobial activities against these pathogens when compared with antibiotic discs.

The tube dilution assay data supports the agar diffusion test results. Plant extracts at a minimal inhibitory concentration (MIC) of 25mg/ml produced the greatest inhibition while the least inhibition was observed at a concentration of 1mg/ml. Representative tube dilution data against *B. cereus* is as follows:



Brine shrimp toxicity studies indicate the MIC value was between 25 and 100mg/ml. Further purification of extracts using activity guided fractionation with TLC, LC, and HPLC are being performed with a focus on isolating saponins, sesquiterpenes and diterpenes, which have already been shown to be present in *Solidago*.

Pacitaxel Stimulates Macrophage Expression of Interleukin–15

Oakley B. LaRue
Faculty Mentor – Thomas M. Walker

Macrophages are phagocytic immune cells involved with surveillance and tumor rejection processes. Many cytokines responsible for lymphocyte recruitment, activation, and differentiation are produced by activated macrophages. Interleukin-15 (IL-15) is a potent lymphocyte signal derived from macrophages and may play a significant role during tumor rejection. The stimuli that trigger macrophage expression of IL-15 are poorly characterized. Paclitaxel (Taxol) is a unique anticancer drug because it demonstrates direct cytotoxicity to cancer cells and serves as a potent macrophage activation agent. Previous work shows that macrophage activation by interferon-gamma (IFN-g) and paclitaxel leads to the release of cytotoxic molecules similar to activation by interferon-gamma (IFN-g) and lipopolysaccharide (LPS). The current studies determined whether paclitaxel could induce expression of IL-15 in the RAW 264.7 murine macrophage cell line. IL-15 expression was measured in non-activated and activated macrophages using reverse transcriptase-polymerase chain reaction (RT-PCR). IL-15-specific primers generated a 325 base-pair product that was visualized using agarose gel electrophoresis. Non-activated macrophage cultures and macrophage cultures activated only with IFN-g, paclitaxel, or LPS expressed low detectable levels of IL-15. Activation of macrophages by IFN-g and LPS or IFN-g and paclitaxel increased expression of IL-15. These results show that paclitaxel can enhance IL-15 expression in macrophages.
These investigations were supported by the National Institutes of Health (CA-74380), Arkansas Space Grant Consortium, and UCA Research Council.

Paclitaxel – Activated Mactrophages Express Costimulatory Surface Molecules Associated with Tumor Rejection

Matthew W. Nix
Faculty Mentor – Thomas M. Walker

The antitumor agent paclitaxel provides macrophages with an activation signal similar to lipopolysaccharide (LPS). The ability of paclitaxel-activated macrophages to express costimulatory surface molecules may enhance immune cell interactions mediated by macrophages and contribute to the clinical efficacy of paclitaxel. This study determined whether activation by interferon-gamma (IFN-g) and paclitaxel induces expression of CD40, CD80, and CD86 on the murine macrophage cell line RAW 264.7. Macrophages activated by IFN-g and LPS were used as positive controls. Flow cytometric analyses revealed that the highest expression of CD40 occurred 24 hours after activation by paclitaxel. CD80 was expressed at levels lower than CD40. In contrast to CD40 and CD80, CD86 was expressed marginally on macrophages activated by paclitaxel. Macrophage co-culture with transforming growth factor-b before paclitaxel

activation suppressed CD40 expression. Macrophage viability and activation status (as determined by nitric oxide release) were confirmed by trypan blue exclusion and the Griess test. These results show that paclitaxel induces expression of macrophage surface molecules that are associated with antitumor responses. These investigations were supported by the National Institutes of Health (CA-74380), Arkansas Scientific Information Liaison Office, Arkansas Space Grant Consortium, and UCA Research Council.

Seed Set, Seed Germination and Seedling Recruitment of *Lonicera Japonica*, Japanese Honeysuckle

S.J. Puterbaugh
Faculty Mentor – K.C. Larson

Many of our endemic plant species are endangered due to the invasion of alien plants. One successful invasion is *Lonicera japonica*, Thunb., Japanese honeysuckle. Plastic life history traits in invasive species can contribute to their ability for successful naturalization. One of these plastic responses is that of reproductive plasticity. The questions I address are: (1) What is the germination rate of field collected seed in Arkansas? (2) What is the recruitment rate of seedlings in a naturalized field population? (3) What is the seed set of the invasive *L. japonica* contrasted to its native congener, *L. sempervirens*? (4) What is germination and recruitment rate of experimental field seed sowings of L. japonica? I found germination rate of *L. japonica* under ideal conditions to be 70%. The recruitment rate of *L. japonica* seedlings in a naturalized population was very low. The study of germination and recruitment of seeds experimentally sowed in the field is still in progress. The results of this life history research on *L. japonica* can be applied to conservation management practices in the effort to preserve our native vegetation in Arkansas.

A Comparative Study of Trenching Behavior in Plusiinae Caterpillars

Rob Tune
Faculty Mentor – David Dussourd

The subfamily Plusiinae contains several caterpillar species that feed on a wide variety of herbaceous plants. Some species feed on plants with canal defenses by cutting a trench across the leaf blade, which severs the canals and deactivates the pressurized system. I designed two experiments to test for differences in trenching ability and to see if any differences correlate with growth and survival on two canal bearing plant species: Italian Parsley, *Petroselinum cripum* (resin canals) and prickly lettuce, *Lactuca serriola* (latex canals). I tested three species of plusiine caterpillars: *Trichoplusia ni, Pseudoplusia includens* and *Rachiplusia ou*.

Larvae of all three species gained mass on excised leaves of prickly lettuce, which have deactivated canals. Only *T. ni* larvae cut trenches and grew well on intact leaves. *P. includens* larvae were variable in trenching ability and in mass change. *R. ou* larvae did not trench and starved as a result. Differences in growth were correlated with trenching ability. In a second experiment, larval survivorship to pupation was recorded. All *T. ni* larvae trenched and survived to pupate. Only one *P. includens* survived, whereas no *R. ou* lived. Plusiinae caterpillars differ substantially in trenching ability and that trenching ability can have profound impacts on larval growth and survivorship on prickly lettuce.

There was no correlation between trenching scores and larval growth on Italian parsley. A few *R. ou* larvae trenched, which was unexpected given their inability to trench prickly lettuce. The ability to trench leads to enhanced larval growth and survivorship on some, but not all plant species with canal defenses.

Evaluation of mCPP-Induced Mouth Movements in Rats as an Animal Behavior which Models Obsessive Compulsive Disorder

Sherin Varghese[1], Synde Canarina[1], Barbara Metzger[1], Jason C. Granger[1], and Jay A. Vacca[2]

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Persons with Obsessive Compulsive Disorder (OCD) have reoccurring, anxiety-producing thoughts and perform repetitive behaviors which can be quite time-consuming. Currently, it is unknown which abnormalities of brain function underlie this relatively common psychiatric disorder (approximately 2-3% of the population have OCD). An animal model of OCD would provide an invaluable research tool because it enables investigative studies of brain function which are not feasible in humans. An animal behavior is considered to be a valid model for a psychiatric illness if: (1) drugs which provoke symptoms in human patients increase expression of the animal's behavior, (2) drugs which alleviate symptoms in patients decrease the behavior, and (3) drugs which are not therapeutically effective in patients do not decrease the behavior.

The first goal of this research study was to evaluate the vacuous chewing mouth movements observed in rats following an injection of mCPP as an animal behavior which "models" the brain state of a human with OCD. An mCPP-induced behavior was selected for study because when administered to OCD patients, mCPP elicits an episode of severe OCD symptoms. The second goal of this research study was to characterize the mechanisms by which mCPP induces the vacuous chewing behavior and to explore which types of drugs suppress this behavior. Preliminary results indicate (a) that mCPP-induced behavior is a valid animal model of OCD, and (b) that although mCPP has direct effects upon the serotonin neurotransmitter system, the dopamine and norepinephrine neurotransmitter systems also play a critical role in mediating this behavior. Knowledge

of the neurological basis of the mCPP-induced behavior may provide insight into the pathophysiology underlying OCD and may enable development of new approaches for the treatment of OCD which alleviate symptoms sooner than do current treatments.

Comprehensive Cataloguing and Study of Arkansas Medicinal Plants

Dan Wandrey
Faculty Mentor – John Choinski

The search for new antimicrobials in higher plants has become more crucial in recent years because of the prevalence of antibiotic resistant bacteria. A proven way to narrow this search is to use ethnobotanical information as a lead. Most current research focuses on exotic habitats around the world, while Arkansas has been left virtually untouched.

My ongoing goal is to collect, catalogue, and do antimicrobial testing on plants known for medicinal use by native Arkansans. So far, I have compiled a list of 50 medicinal plants. I have collected 10 plants from the list and have run agar diffusion assays on six of these using four different bacteria: *Escherichia coli*, *Bacillus cereus*, *Staphylococcus aereus*, and *Salmonella choleraesuis*. Of these six, extracts from *Cephalanthus occidentalis* and *Zanthoxylum clava-herculis* showed no activity. *Callicarpa americana* extracts showed activity against *Bacillus* and *Staphylococcus*. *Liquidambar styraciflua* extracts showed activity against *E. coli*, *Bacillus* and *Staphylococcus*; and extracts from *Rhus glabra* showed activity against all four.

I am also using a computer scanner to create high-quality images of collected plants. These images, the antimicrobial information, and general plant data (native usage, plant location, distribution, etc.) are being organized into a comprehensive listing of Arkansas medicinal plants. This listing will be useful as a guide to antimicrobial activities in Arkansas plants and a springboard for further research. This is the first such project on medicinal plants to concentrate on Arkansas species.

The Role of Intracellular Acidification in the Progression of Apoptosis

Britt Young
Faculty Mentor – Steven W. Runge

Apoptosis is the cascade of events responsible for the elimination of abnormal and unneeded cells in multicellular organisms. This process is responsible for turnover of epithelial cells lining the gastrointestinal tract as well as proper embryological development. Apoptosis involves activation of an extended biochemical pathway following exposure to certain cell death stimuli. Two main aspects of this pathway include caspase activation followed by an intracellular acidification (IA). Caspases are a family of cysteine proteases which are the central enzymes of the apoptotic pathway. IA has been shown to stimulate apoptosis. However, it is not known of the IA is necessary for apoptosis to occur properly. This study will stimulate apoptosis in a mouse fibroblast (C3H-10T1/2) and a human breast cancer (MDA-MB-468) cell line. Apoptosis will be stimulated by chelerythrine, amiloride, ceramide and serum withdrawal (SW). Chelerythrine stimulates apoptosis by inhibiting protein kinase C (PKC). Amiloride is a potent inhibitor of the Na+/ H+ antiporter. Ceramide acts as a second messenger of tumor necrosis factor-a. The mechanism by which SW induces apoptosis is unknown. The normal IA involved in apoptosis will be inhibited by clamping the cells at an alkaline pH (7.4) with the proton ionophore carbonyl cyanide m-chlorophenylhydrazone (CCCP). Apoptosis will be quantitated by the trypan blue exclusion method. Caspase activity will also be monitored by the cleavage of poly-(ADP-ribose) polymerase (PARP). The hypotheses of this study are that by clamping the pH, apoptosis will be inhibited and PARP cleavage will remain at normal levels.

Computational and Experimental Analysis of Mitomycin C-DNA Interactions

Micah Abrams and Scott Miller
Faculty Mentor – Patricia Draves

Computational and experimental analyses play a major role in the elucidation of structural and binding properties of large molecular systems. We are examining the interaction of the antitumor antibiotic, mitomycin C with DNA using the molecular modeling package SYBYL 6.5 and by denaturing gel electrophoresis. Computational investigation of the structural and binding properties of mitomycin C with B-form DNA has been completed and we are currently examining the properties using alternative DNA conformations. Experimentally, quantitative determination of binding efficiency to several B-form DNA molecules is underway. Comparison of mitomycin C binding to alternative DNA conformations will be presented. Results from this study will demonstrate the importance of conformational effects in DNA-drug interactions and their potential impact on the drug's potency.

Where is the Linker Histone on the Nucleosome?

Charity Billingsley
Faculty Mentor – Patricia Draves

Chromatin is the true substrate in all biological processes involving DNA within the eukaryotic cell nucleus. Recent work has demonstrated that the organization of DNA within the chromatin complex can exert both a positive and negative influence on these processes, i.e., transcription and replication. The primary unit of chromatin structure is the nucleosome. It is comprised of two turns of DNA wound around a protein cylinder of core histones. The association of another histone (the ôlinker histoneö) on the outside of the nucleosome completes the structure and plays a key role in hierarchical folding of chromatin. Despite its crucial role, the exact location of the linker histone is uncertain. To address this issue, an antitumor antibiotic that binds to DNA in a sequence specific manner will be used to map the location of the linker histone binding site. To carry out these studies purification of the globular domain of the linker histone H5 (GH5), core histones, and DNA systems are being performed. Successful purification of the core histones (>100mg) and DNA (5mg) are complete and the purification of the GH5 is underway. Purification schemes and characterization results will be presented. The results of this study will help provide a clearer picture of the role of GH5 in chromatin folding and in the control of key DNA processes.

State-Specific Gas Phase Association Reactions of the Group 11 Ions

Aimee Lasater and Hunter Holcomb
Faculty Mentor – William Taylor

The chemistry of gas phase transition metal ions is well-known to be state-specific. This characteristic can potentially provide sensitive control over product formation. In this study, the gas phase reactions of Cu^+, Ag^+, and Au^+ with several small organic molecules were examined. The reactions were carried out in a He buffer at room temperature using a drift cell reactor operated under near-thermal conditions. Metal ions were produced within a sputtering glow discharge. Discharge conditions were manipulated for each metal to produce the desired distribution of excited and ground state ions. Reactant ion state distributions were monitored using electronic state chromatography. Results indicate that association products are formed in all of the reactions. In most cases, these association products are formed exclusively from the ground state of the metal ion; however, excited states were observed to contribute to adduct formation in some cases. These observations suggest that in these latter cases, the reactant neutral initially relaxes the excited state to the ground state, then associates. This presents the interesting possibility that for some reacting systems, the association product is formed in both primary and secondary steps from the same reactant ion.

Monte Carlo Simulations of Sulfate Aerosols

Pamela Seamans
Faculty Mentor – Jeffrey Draves

Sulfate and bisulfate anions are known to act as nucleation seeds for aerosol growth in both the stratosphere and troposphere, with subsequent impacts on visibility, forest decline, and ozone depletion. Since classical nucleation theory is often in complete disagreement with experimental results for polyatomic anionic systems, we have investigated small sulfate water systems using the Monte Carlo method. Results indicate that at tropospheric conditions, 13 ± 0.56 waters occupy the first solvent shell of sulfate and form a highly ordered hydrogen bonding environment for subsequent water attachment. Results under stratospheric conditions indicate that 11± 0.33 waters occupy the first solvent shell and again form a highly ordered hydrogen bonding environment. The presence of this highly ordered hydrogen bonding environment leads to an ordered second solvent shell, a characteristic which appears to be unique to the sulfate anion and may be the characteristic which governs nucleation growth for this system. We have also observed that at 197K, the sulfate aerosols do not exhibit solid like character but are clearly liquid in nature.

Robotic Shadowing and Gesture Recognition

Nathan Barnes, Lee Duncan, Tim Johnson, and Tom Holtz
Faculty Mentor – Harold Forbes

A robotic assistant is a robot unit which works directly with a human, performing tasks as directed without direct telerobotic control. We are working on two aspects of this behavior, shadowing and gesture recognition. Shadowing is the behavior enabling the robot to follow a specific master using, in this case, sonar for detection. Gesture recognition is a form of visual communication enabling the master to easily and intuitively give commands to the robot. This presentation describes the algorithms and hardware that we are using to implement these behaviors.

Some Applications of Formal Language Theory: Classifications of Animals

Mohammad Bhuiya and Dalegreco Haney
Faculty Mentor – D.S. Tomer

Concepts of formal grammars/languages as developed by Panini (420 B.C. or earlier) and then by Noam Chomosky (1954) are used to describe the syntax of modern programming languages. The standard parsing algorithms as developed in the field can be applied to check whether a speech pattern of an animal – represented by a string of terminals is a formal grammar – is parsable or not with respect to a common basic formal grammar representing the animal kingdom. If the animal speech patterns are parsable with respect to a common grammar, then the animals are likely to be related based on their speech patterns. We have used the top-down left-to-right parsing algorithm for a context-free grammar to look at the speech patterns of animals: Baboon, Chimp, and Gorilla – all with respect to a common monkey grammar. We are still looking for basic common formal grammars and their speech patterns for various popular animals/birds so that the parsing algorithms can be used to group them. Also, we don't expect that all such grammars if constructed will be context-free grammars.

Some Reflections on the Y2K Problem

Mohammad Bhuiya and Dalegreco Haney
Faculty Mentor – D.S.Tomer

The Y2K problem – affectionately called the Millennium Bug – is one of the largest problems ever faced in the computing discipline. The early programmers who are responsible for this problem did not expect this. The Gartner Group is estimating worldwide cost of about 1.2 trillion dollars including 600 million dollars in North America. Some people are aware of this problem, but no preparations are being made. We have collected some information about UCA, the state of Arkansas, and the problem at the national and international levels. As an end product of this project, we are planning to develop some literature and flyers to educate people about this problem and possible solutions available in the market. This problem is handled very poorly in other countries where no public/government agencies are equipped to address a problem of this magnitude. Hopefully, today's programmers/software developers will take the area of software engineering seriously and we will not leave such a mess in the future.

Staffing and Efficiency Concerns at CRMC Laboratory

Erin Weese
Faculty Mentor – Todd Smith

Data can be very informative if one can find the correct key to unlocking the information contained within. Our client, the laboratory manager at CRMC (Conway Regional Medical Center), had concerns about the operational efficiency of the laboratory and its staff regarding the collection and analysis of blood samples. In particular, our client was hoping to show a positive correlation between the experience of the lab staff and the collection time, as well as between the experience of the lab staff and the time to run each analysis. Our client also wanted to show the priority classification (Stat=immediate, As soon as possible, Routine) of the specimen had a positive effect on the amount of time needed to collect and run the specimen. Since the laboratory is required to keep records, there was an abundance of data available for analysis.

With these concerns in mind, the laboratory staff supplied us with a random sample of data including: 1) the amount of time to collect each sample, 2) the amount of time to run each sample, and 3) information about the lab staff (experience). We analyzed these data using linear regression and analysis of variance techniques. Linear regression uses the measurements from several input (independent) variables to estimate or predict the value of a specified output variable. Analysis of Variance (ANOVA) compares the values of the output variable for each level of the input variables to determine if the input variables are necessary to make an accurate prediction of the output variable. The results were not only unexpected, but also provided valuable information for our client to use in making decisions about laboratory operations.

Addendum:

Department of Mathematics

Using Technology to Connect the Empirical and Deductive Aspects of College Geometry

Sandy Dunlap
Faculty Mentor – Jean McGehee

In an ideal world, college students would have no trouble extending their traditional high school knowledge of Euclidean geometry to the college course. However, learning geometry at a more rigorous level requires a strong connection between empirical activity and deductive work. Research shows that students usually learn proof algorithmically and fail to connect deductive work to mathematical activity, especially constructions. This study shows how software can make up for deficiencies and extend understandings.

Non-Rutherford Scattering of Protons from Carbon*

Donald Benson, Mark Denton, Chris Lynch, and Robert Sullivan
Faculty Mentor – Rahul Mehta

Rutherford scattering occurs when a beam of protons is scattered from the target nuclei of large atomic number. The positively charged protons are scattered by the Coulomb barrier created by the much larger positive charge of the nuclei. The charge on a carbon nucleus, however, is not large enough for true Rutherford scattering to occur.

This experiment used a 2.5 MV Van de Graaff accelerator to create a proton beam. The 1.5 MeV proton beam was scattered from a carbon target and collected by a silicon surface barrier detector. The data was collected and analyzed by a PCA III data acquisition card installed in a Pentium computer. The yield of scattered protons per incident number of protons was measured as a function of scattering angles. The cross sections for scattering were then calculated from the data. The measured scattering cross sections for protons from a carbon target were compared to the theoretical Rutherford scattering cross section values. The variation from theory was small for small scattering angles, but it was quite large for larger angles.

*We would like to acknowledge the assistance of Mohammed El- Bouanani and J.L. Duggan of Van de Graaff accelerator lab at University of North Texas.

Sound Propagation in Shallow Water Environments

Brian Lemon
Faculty Mentor – Carl K. Frederickson

Acoustic data taken at the Naval Research Laboratory in the summer of 1998 has been analyzed. Measurements were made of the sound reflected from buried and partially buried aluminum spheres. Two types of measurements were made. One used a stationary line source while scanning the receiver. A second used a spherical source that moved with the receiver. Time data was recorded at various receiver positions. MATLAB is used to clean the data so as to isolate the signal reflected from the sphere from the background noise of the tank. The time data was then Fourier transformed and compared to theoretical calculations. Color plots are used to display an entire scan in either the time domain or the frequency domain.

Analysis of Seismic Signals in Porous Materials

Chris R. Lynch
Faculty Mentor – Carl K. Frederickson

The purpose of this project is to assemble a data acquisition system that will record and analyze acoustic and seismic signals. The system includes a personal computer, an AD/DA data acquisition card, and software to analyze the data. This system will digitize up to 8 analog signals simultaneously at rates up 39 kS/s. This system will be used to detect and analyze acoustic signals in model porous materials. The data collected will then be used to determine characteristics of the materials. This information will then be compared to theory.

The Investigation of Kinematical Scattering Factor for Incident Proton Beam*

Chris Lynch, Donald Benson, Mark Denton, and Robert Sullivan
Faculty Mentor – Rahul Mehta

The purpose of this experiment was to measure the kinematical scattering factor and to compare it with the relation for it derived from conservation principles. A proton beam of 1.5 MeV, from a Van de Graaff accelerator, was scattered from a carbon target and collected by a silicon surface barrier detector. The measurements of energies of the scattered particles were made as a function of scattering angle. The energy response of the silicon surface barrier detector for proton scattering of gold and of carbon at scattering angle of 145° was used to calibrate it. The data was collected and analyzed by a PCA III data acquisition card installed in a Pentium computer. The kinematical scattering factor was determined by taking the ratio of scattered proton energy to incident beam energy. The measured values were then compared to values calculated from theoretical kinematics scattering factor equation.

*We would like to acknowledge the assistance of Mohammed El- Bouanani and J.L. Duggan of Van de Graaff accelerator lab at University of North Texas.

Rutherford's Gold Foil Scattering Experiment*

Robert Sullivan, Donald Benson, Mark Denton and Chris Lynch
Faculty Mentor – Rahul Mehta

This experiment, conducted at the Van de Graaff accelerator laboratory at University of North Texas, involved the validation of Rutherford's gold foil scattering equation. A proton beam accelerated to 1.50 MeV was fired perpendicularly to a gold target of thickness 27 $\mu g/cm^2$. The scattered protons were detected and collected by a silicon surface barrier detector. A yield of one thousand counts generating 1 μC of integrated charge was collected in a Faraday cup for scattering angles ranging between 35 and 165 degrees. The energy response of the silicon surface barrier detector for proton scattering of gold and of carbon at scattering angle of 145° was used to calibrate it. The data was collected and analyzed by a PCA III data acquisition card installed in a Pentium computer. A computer program was used to determine the net count by a peak stripping program. The measured scattering cross section for protons from the gold target were compared to the theoretical Rutherford scattering cross sections. The results for the experimental cross section were within 5 % of theory, and all but three angles created cross sections that were three standard deviations apart from each other.

*We would like to acknowledge the assistance of Mohammed El- Bouanani and J.L. Duggan of Van de Graaff accelerator lab at University of North Texas.