### College of Natural Sciences and Mathematics Annual Student Research Symposium

### May 8, 2002 2:30-3:30 First Floor Lobby Main Hall

### TITLES

#### LIFE SCIENCES

Water flow receptors in a marine slug Jeffry Blackwell Faculty Mentor: J.A. Murray

Do alanine transport activated apical membrane potassium channels regulate enterocyte volume? Thomas Edwards Faculty Mentor: Dr. Mike Moran

Structural and Behavioural Adaptations of the Corallivore *Coralliophila abbreviata* (Lamarck) for Effective Feeding on Scleractinian Corals Reia Guppy Faculty Mentor: Paul Hamilton

Do milkweed glues or poisons trigger vein severance by monarch caterpillars? Matthew Helmus Faculty Mentors: David Dussourd, Patricia Draves and Katherine Larson

Does L-alanine Stimulated Na<sup>+</sup> Absorption Stimulate the Delivery of IntracellularVesicles to the Apical Plasma Membrane in Seahare Intestine? Robert Keeton Faculty Mentor: Mike Moran The role of intracellular acidification in apoptotic progression Nelly Norrel Faculty Mentor: Steven W. Runge

Role of a single neuron in turning while crawling in the marine slug *Tritonia diomedea* Roger Redondo Faculty Mentor: James Murray

The Role of Microtubules in Intracellular Vesicular Trafficking and the Regulation of Apoptosis in Cultured Cells Dana Strassle Faculty Mentor: Steven W. Runge

#### MATHEMATICAL AND PHYSICAL SCIENCES

Modeling Polymerization Trey Bass Faculty Mentors: Richard Tarkka and Danny Arrigo

Impact of Bridge Construction on the Water Quality of Tucker Creek Brent Baker, David Johnson, Matt Schroeder, TUI Graphics Library Jeremy Goldberg, Jason Cullum, Daniel Pollock Faculty Mentor: Wayne Brown

Time independent Schrödinger potentials Brandon S. Lindley Faculty Mentors: Danny Arrigo and Fred Hickling

Exact Solutions to Approximate Equations Casey Milford and Brandon Willis Faculty Mentors: Danny Arrigo and Fred Hickling

Calcogen Selectivity by Nickel Controls Coordination Geometries in Model Biochemical Systems David L. Nutt Faculty Mentor: Patrick J. Desrochers

Numerical Solution of Helmholtz Equation Eugene Rathfon Faculty Mentor: Guy Bernard

SCIENCE AND MATHEMATICS EDUCATION

Literature as a Manipulative in a Secondary Level Mathematics Curriculum Matthew Dalke Faculty Mentor: Carolyn Pinchback

Improving mathematics education in Arkansas Large-scale assessment can be an agent of change Audri McCready Faculty Mentors: Linda K. Griffith and Jean J. McGehee

gummed up or trapped in congealing latex. Milkweed latex also contains heart poisons(cardenolides), which are toxic to most animals. Monarchs have evolved behaviors that circumvent the latex defense. Before eating a milkweed leaf, final instar larvae transect one or more veins, thereby severing the latex canals. Larvae then feed distal to the cuts where the milkweed plant no longer exudes latex. If a monarch encounters latex when feeding, it will return to chew further on its previous vein-cut. Although vein cutting clearly functions to reduce larval contact with latex, it is not yet known what characteristic of latex stimulates this behavior. I tested if stickiness and/or cardenolides cause monarchs to cut further on a previous vein-cut. Larvae tested with fresh Asclepias curassavica latex all returned to chew on their vein-cut, while larvae tested either with sticky polyethylene glycol or a cardenolide solution did not. When A. curassavica latex was centrifuged, the pellet fraction typically did not cause larvae to rechew, whereas the supernatant did. These data suggest that cardenolides and stickiness are not triggers for vein cutting, but that the supernatant fraction contains another chemical stimulant. The supernatant can now be fractionated further to test exactly what chemical elicits vein cutting.

# Does L-alanine Stimulated Na<sup>+</sup> Absorption Stimulate the Delivery of IntracellularVesicles to the Apical Plasma Membrane in Seahare Intestine?

### Robert Keeton Faculty Mentor: Mike Moran

The major long-term objective of this project is to determine the mechanism(s) responsible for the alanine-stimulated increase in enterocyte plasma membrane potassium conductance ( $G_k$ ). Stimulation of Na<sup>+</sup> absorption in *Aplvsia* intestine with alanine increases enterocyte intracellular osmolarity and induces enterocyte swelling by either osmosis or by cotransporter-induced water entry, or both. In response, enterocytes increase apical membrane  $G_{\kappa}$ , which stimulates  $K^+$  and accompanying anion efflux from the cell. The loss of  $K^+$  and anions from the cell is followed by that of water. Thus, cell volume is restored to near pre-nutrient levels. Recent studies of exocytosis and membrane capacitance in Aplysia intestine suggest that the alanine-induced increase in plasma membrane G<sub>k</sub> results from exocytic insertion of K<sup>+</sup> channels into the apical membrane. If alanine increases apical membrane  $G_{K}$  by exocytic insertion of  $K^{+}$ channels, intracellular vesicles carrying K<sup>+</sup> channels must translocate and fuse with the apical membrane. Hence, we should be able to label these vesicles with a biotinylated lectin that binds specific sugar residues on the cell surface. These have a high affinity for avidin conjugated fluorescent probes and enter cells by constitutive endocytosis. However, determining the appropriate lectin to use as a membrane marker and the procedure in which to apply the lectin has proven difficult. Using a specially designed chamber, we have screened several biotinylated lectins for their affinity to the apical surface of Apylsia enterocytes. Biotinylated wheat germ agglutinin, succinylated wheat germ agglutinin, and concanavalin A successfully label the apical surface of the Aplysia

enterocytes. Therefore, these lectins can be used to study vesicular trafficking in the Aplysia enterocytes.

### The role of intracellular acidification in apoptotic progression

### Nelly Norrel Faculty Mentor: Steven W. Runge

Apoptosis, or programmed cell death, is an essential mechanism for the development and maintenance of multi-cellular organisms. In recent years, significant advances have been made toward achieving full understanding of the many steps in the biochemical pathways of apoptosis, but many aspects of this process are still poorly understood. Intracellular acidification is an event that occurs in many cell types during apoptosis, and acidifying the intracellular environment is sufficient to induce apoptosis. Unfortunately, the precise function and significance of intracellular acidification to the cell death process is still unknown. In this study, apoptosis is induced in cultured mouse fibroblast cells by various stimuli, including enzyme inhibitors and UV irradiation. At the same time, cells in duplicate cultures have their internal pH locked at 7.4 to prevent intracellular acidification results in a significant decrease in the levels of apoptosis observed, then intracellular acidification is likely a required step for apoptosis. Gaining a full understanding of how intracellular acidification

Foot contractions are initiated by neurons located in the pedal ganglia of the brain. Pedal 3 (Pd3), a 250µm dark orange cell, has been shown to receive synaptic input from flow receptors (Murray 1992) and to be necessary for turning (Murray 1994). We have recorded video of this turning behavior in a freely-crawling slug on which two fine wires have been glued over the surface of the brain, above Pd 3. The slug was placed in a flume (i.e. stream channel) to induce their natural tendency to turn upstream. Cameras sent views of the left and right sides of the foot, and of the bottom of the foot to a video mixer. The composite video was recorded synchronously with the firing activity of the Pd 3 neurons for off-line analysis. We have investigated whether Pd3's activity is correlated with turns and whether Pd3 stimulation is sufficient to elicit turning in *Tritonia*.

### The Role of Microtubules in Intracellular Vesicular Trafficking and the Regulation of Apoptosis in Cultured Cells

#### Dana Strassle Faculty Mentor: Steven W. Runge

The Na<sup>+</sup>/H<sup>+</sup> exchanger (NHE) is an integral membrane protein that regulates intracellular pH by exchanging one intracellular H<sup>+</sup> for one extracellular Na<sup>+</sup>. Cells respond to intracellular acidification by trafficking NHE in vesicles from the cytoplasm to the plasma membrane in an attempt to maintain normal intracellular pH. This study concentrates on the involvement of microtubules in trafficking vesicles from the cytoplasm to the plasma membrane where they, and the proteins they carry, are inserted by exocytosis. Human breast cancer cells were incubated in acidified media at pH of 7.4, 6.75 and 6.25 and the proton ionophore, carbonyl cyanide m-chlorophenylhydrazone (CCCP). Treatments involved incubation of cells with acidified media and subsequent addition of the anti-microtubule agent, Taxol, and incubation of cells in media of normal pH containing Taxol followed by subsequent incubation in acidified media. The percent of apoptotic verses percent adherent cells was measured in each experiment after 12 hours of incubation, 24 hours and 48 hours. Breast cancer cells incubated at pH 7.4 exhibited the highest percent apoptosis. These results were opposite of what was expected. Previous experiments with embryonic mouse fibroblast cells showed and increase in the percent of apoptotic cells with decreasing pH. Subsequent incubation of the breast cancer cells in media of normal pH, 7.4, with CCCP revealed an increase in percent apoptosis in the absence of other apoptotic triggers. It was concluded that CCCP is toxic to breast cancer cells and will be replaced in future experiments with another proton ionophore, nigericin. Development of anti-cancer treatments has not focused on the role microtubules play in vesicular trafficking, but rather on their role during cell division. Vesicular trafficking is dependent upon microtubules and other cytoskeletal components. An examination of this mechanism and its use by cancer cells, during regulation of intracellular pH in an acidic environment, may ultimately lead to the identification of novel chemotherapy targets for cancer in the future.

## MATHEMATICAL AND PHYSICAL SCIENCES

Vibrational Analysis of 1,2-Dichlorotetrafluoroethane

G.T. Dobbs, J. M. Moix, K.L. Reynolds, J.R. Rucker, S.E. Sparks, D.C. St. John which is solvable by reducing it to a linear fourth order PDE. Solving for f(x) generates new classes of solvable wave equations. Finally, these forms are converted into the wave speeds for the standard variable speed wave equation by solving a nonlinear second order integral equation.

### TUI Graphics Library

### Jeremy Goldberg, Jason Cullum, Daniel Pollock Faculty Mentor: Wayne Brown

TUI (Three-dimensional User Interface) is a set of software functions that allows a programmer to present a graphical interface between a user and an application. The interface can consist of 2D and/or 3D elements. TUI attempts to be both easy to use and powerful. One set of functions allows a programmer to create an interface quickly and easily with reasonable default values. Another set of functions gives the programmer complete control over every aspect of the interface elements.

An important feature of the library is its use of relationships between graphical elements. The programmer can set the position, rotation, size, and attributes of an interface element in relation to any other element. This allows the programmer to easily place elements in the interface environment. This also maintains the relative relationships of graphical

### Exact Solutions to Approximate Equations

### Casey Milford and Brandon Willis Faculty Mentors: Danny Arrigo and Fred Hickling

Most current techniques used to approximate solutions to partial differential equations (PDEs) start with a given equation and provide an approximate solution using a variety of techniques. An alternate scheme for approximating solutions to an equation is to find an approximate equation for which exact solutions are known. We will use this alternate scheme to find solutions to Schrodinger's equation.

Until recently, there have been very few potentials for which exact solutions of Schrödinger's equation were known. Given the recent extension to this class of potentials, we have created and implemented an algorithm that approximates any given potential, V(x), by intelligently manipulating members of the recently extended class of potentials. This will eliminate most of the error currently associated with approximate PDE solutions, by providing an approximate equation for which exact solutions are known.

### Calcogen Selectivity by Nickel Controls Coordination Geometries in Model Biochemical Systems

### David L. Nutt Faculty Mentor: Patrick J. Desrochers

Cysteine, selenocysteine, and thioethers are essential calcogen(O, S, Se) amino acids and substrates in three of the four known classes of nickel enzymes. Complementary theoretical and experimental results show that nickel's discrimination between calcogen amino acids determines its coordination geometries in model biochemical systems. Kinetically stable trigonal bipyramidal geometries are obtained for sulfur and selenium amino acid residues (Cys); comparable oxygen forms (Ser) yield square pyramidal geometries (Tp\*Ni(E,N)) where E = O, S, and Se.) Trigonal bipyramidal geometries observed for sulfur and selenium spectroscopically match structurally characterized complexes involving cysteine and its ethyl ester. Optimal pi overlap stabilizes Tp\*Ni(S,N) and Tp\*Ni(Se,N). Alkylation or oxidation of these complexes reduces this pi overlap, resulting in loss of the trigonal bipyramidal geometry. Alkylation, but not oxidation, is reversible, and oxidation of the selenium form is considerably faster than its sulfur derivative. The square pyramidal geometry obtained for oxygen is confirmed by comparative spectroscopic measurements with Tp\*Ni(acac) and published nickel-acac complexes. Oxygen's diminished pi overlap with nickel prevents ethanolamine from stabilizing the trigonal bipyramidal geometry. These results help define the role of cysteine (both S and Se forms) in nickel-hydrogenase and carbon monoxide dehydrogenase enzymes as well as the cysteine-targeted toxicity of this metal.

### Numerical Solution of Helmholtz Equation

### Eugene Rathfon Faculty Mentor: Guy Bernard

The Helmholtz equation is a differential equation that describes the steady vibrations of phenomena modeled by the wave equation, e.g. sound propagation in air. Applications of this equation arise in acoustics, seismology, sonar and radio transmission, to name just a few. This research project (in progress) deals with the one dimensional Helmholtz equation  $u_{xx} + k^2(x) u = f(x)$  where -R < x < R denotes the position in one dimensional space, u(x) the amplitude of the vibrations (to be determined) and k(x) describes a property of the medium e.g. speed of sound in air.

In the many applications of Helmholtz equation of interest in engineering, the wave number k(x) is not constant. In this case, analytical methods to solve these equations do not exist and engineers must resort to computer generated approximations of their solutions. The objective of this research is to devise a numerical method capable of approximating the solution of Helmholtz equation in the difficult case where R >> 2 / k(x). The numerical method will consist of a finite difference method in combination with a multigrid solver which will be constructed speh wifinal mIyo deTJ0 -1.165TD0.comirc

# SCIENCE AND MATHEMATICS EDUCATION

Literature as a Manipulative in a Secondary Level Mathematics Curriculum

Matthew Dalke Faculty Mentor: Carolyn Pinchback

This research is designed to test qualitatively the effectiveness of using literature in a secondary mathematics curriculum. Much has been done at the elementary level already with integrating mathematics and literature, one example being a study conducted by Pamela Halpern. In her article "Communicating the Mathematics in Children's Trade Books Using Mathematical Annotations' for the NCTM 1996 yearbook, Halpern states that in her study using a sample of 209 children in grades one through three, 81.8% of the students preferred books with mathematical annotations as opposed to those books without the annotations. Such reasons as to why they liked the annotated books better were "The mathematical annotations made reading the book more enjoyable" and "The mathematical annotations made the book 'easier to understand' and communicated the mathematics more clearly." And if this would work at the lower levels, why would it not work at the secondary level? Literature can be used to take the mathematical concepts taught in high school that are often thought of as abstract and obscure and show how they can be applied to an everyday situation. Currently we are looking at utilizing the short story "How Much Land Does a Man Need" by Leo Tolstoy to teach algebra, geometry, and trigonometry at the secondary level. I have already created my own adaptation of this story that will be given to the students in each of the classes. Also, I will be looking at adapting a portion of the story *Gulliver's Travels* by Jonathan Swift to use.

> Improving mathematics education in Arkansas Large-scale assessment can be an agent of change

Audri McCready Faculty Mentors: Linda K. Griffith and Jean J. McGehee

Two issues in the forefront of mathematics education are state testing/accountability programs and effective professional development. When the testing extends beyond norm-referenced tests to criterion-referenced tests and emphasizes curriculum alignment

curriculum alignment. The data collected in the Professional Development and Curriculum Alignment Project (PDCA) is used to determine the following:

- 1. Long-term trends in student achievement based on Benchmark test data in grades 4,6, and 8
- 2. Annual growth in student achievement based on a pre/post test
- 3. Impact on teacher knowledge and practice based on classroom observations and teacher/scholar interactions

As a graduate assistant I have collected and analyzed the following data for this program:

- š Benchmark data for grades 4, 6 and 8.
- š Pre/post tests based on released Benchmark items for each of the grades 3-8 to demonstrate annual growth in student achievement.

While PDCA has extended to several school districts in the state, this presentation focuses on two school districts in northeast Arkansas. Eighth grade trend data and