

SCHOOL OF SCIENCE AND MATHEMATICS

# Undergraduate Research Poster Display

Spring 2006

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• M A T H E M A T I C S •

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# Table of Contents

	<u>Abstract Number</u>
Biology.....	1-17
Chemistry.....	18-19
Computer Science.....	20-25
Earth Sciences .....	26-33
Mathematics.....	34
Physics.....	35-36
List of Undergraduate Research Students.....	i-v
Index of Authors.....	vi-vii

Note: The names of Millersville University faculty advisors are designated by an asterisk (\*) in the abstracts.

# Biology

## 1. Conditional Discrimination Learning and the Importance of Experimental Design with *Octopus bimaculoides*

Blakeslee, Carrie and Boal, Jean\*

Department of Biology, Millersville University, Millersville, PA 17551.

Previous research has demonstrated that octopuses are capable of conditional discrimination learning (CDL), a form of complex learning; however the sample size was quite small (n=4). CDL was explored further in a series of five experiments using *Octopus bimaculoides*. Each experiment built on the previous experiments, implementing changes in experimental protocol and design. A meta-analysis was conducted on four of the experiments to analyze the cumulative results; a fifth experiment was then conducted. Although improvements in the octopuses' performances were found throughout the series of experiments, CDL was not definitively demonstrated. If octopuses demonstrate CDL, then it places them at level five of the eight levels described in Thomas's hierarchy of complex learning (1980). Few invertebrates have demonstrated learning at this level. It is evident that, when working with octopuses, the details of the experimental design are critical.

## 2. Evaluation of Cultural Techniques to Improve Survival and Growth of Transplanted Tree Seedlings in a Riparian Buffer

Cawley, Michael D. (MU 2005); Swords, John A. and Yocom, Daniel H.\*

Department of Biology, Millersville University, Millersville, PA 17551

In the first year of a long-term study to examine cultural techniques that might improve survival and growth of transplanted, container-grown trees in riparian reforestation projects, four tree species, green ash (*Fraxinus pennsylvanica*), silver maple (*Acer saccharinum*), white oak (*Quercus alba*), and red oak (*Quercus rubra*), were planted in a pasture alongside a small stream in Manor Township. At the time of planting (May 2005), the trees were treated with combinations of three different cultural practices: 1) with and without tree mats, 2) with and without time-release fertilizer, and 3) with and without mycorrhizal fungus inoculum. For each species, six replicates of every possible treatment combination were randomly planted (192 trees total). In September 2005, the seedlings were assessed for survival and growth. The mortality rate for the trees was 10.4% (20 dead/192 planted) with the following individual species mortality rates: white oak at 22.9% (11 dead/48 planted), red oak at 8.3% (4 dead/48 planted), silver maple at 8.3% (4 dead/48 planted), and green ash (2.1% (1 dead/48 planted). Forty-five percent (9 of 20) of the dead trees showed signs of rodent damage (incisor marks on cut stems). Growth of green ash was significantly improved with application of tree mats and fertilizer. The mycorrhizal fungal inoculum had a significant negative effect on growth of silver maple, while fertilizer had a significant positive effect on maple growth. For white oak, none of the treatments had any significant effects on tree growth, although improvement in growth was noted with the addition of mycorrhizal inoculum. For red oak, there was a nearly significant interaction between the fertilizer and tree mat treatments, but there was no clear pattern of growth improvement with any single treatment. Survival and growth of these trees will be assessed annually for the next 5 years.

### **3. Seasonal Distribution of the Gelatinous Tunicate *Thalia democratica* off Chincoteague Island, Virginia**

Day, Melissa C. and Ambler, Julie W.\*

Department of Biology, Millersville University, Millersville, PA 17551.

*Thalia democratica*, which are pelagic tunicates, are important herbivores of small phytoplankton in marine food chains and can form extensive blooms. It is difficult to predict the abundance and distribution patterns of these tunicate blooms, although these blooms were observed on single sampling cruises during summer 1998 and 2004. In the ongoing research, zooplankton were sampled on an approximately bi-weekly basis, with a vertical tow using an 80 µm mesh size net, at 5 or 6 stations off Chincoteague Island, VA. The abundance and distribution of *Thalia democratica* were correlated with vertical profiles of temperature and food abundance in the form of fluorescence. *Thalia democratica* were identified by lifecycle stage: solitary with embryo, solitary with no embryo, aggregate with stolon, aggregate with no stolon. The life cycle of *Thalia democratica* is quite complex as it reproduces both sexually and asexually. Rapid asexual reproduction allows the organism to create massive blooms of individuals in chains. We found these chain individuals to be the most abundant life cycle stage present. Intact chains were not collected, but each chain can hold around forty individuals. We estimated this figure from the embryonic individuals counted in the stolon, which develops inside solitary individuals. *Thalia democratica* were present at stations 4-6 (~46 km offshore) during August, September and October cruises but were most abundant during the August 4, 2005 cruise when seasonal thermoclines were more pronounced. Since only vertical tows were performed, we do not know if *Thalia democratica* were most abundant in surface waters or below the thermocline where maximum fluorescence (phytoplankton) occurred. In summer 2006, a Tucker trawl will be used to sample specific depth intervals; namely at the surface, in the thermocline and below the thermocline, and abundance of *Thalia democratica* can then be correlated with phytoplankton abundance and size classes.

### **4. Similarities in *Chlorella* Viruses Cannot Be Predicted By Their Geographic Locations**

DiStefano, Jennifer; Mone, James\* and DiBartolomeis, Susan\*

Department of Biology, Millersville University, Millersville, PA 17551

*Chlorella* are unicellular green algae that exist symbiotically within certain species of hydra and paramecia. Once the algae are removed from their host, a *Chlorella* virus is capable of destroying the entire algal population within 24 hours. To study their distribution patterns, *Chlorella* viruses from 11 different ponds along the northeast coast of the United States were isolated and grouped by their restriction fragment length polymorphism (RFLP) patterns. A group of 19 viruses was selected for further analysis by Southern hybridization and western blot. As a result, restriction enzyme fragments of the same size in the RFLP patterns of different viruses were correlated with similarities in the DNA sequences of these fragments as determined by Southern hybridization. Most of the analyzed viruses shared two specific restriction fragments. Since these two common DNA sequences correlated to portions of the already sequenced PBCV-1 *Chlorella* virus, it is predicted that these two regions encode a lipoprotein lipid attachment site, a protein with an ATP/GTP-binding site motif, a cytosine methylase, and a metallopeptidase. Analysis of viral proteins by western blot revealed a high degree of serologic cross-reactivity. Two common proteins were found in most of the viruses examined. These are predicted to be a major capsid protein and a protein with an ATP/GTP binding site motif.

Finally, although similarities in RFLP, Southern, and western analyses were observed between viruses from different ponds, their similarities did not appear to correlate with their geographic locations as the virus collected from ponds of close proximities and also ponds more than 495 kilometers apart shared similarities in their DNA sequences and proteins.

## **5. Antibody Attachment to Nanowire Arrays**

Dower, Nicholas J.; Pelliccia, Jose L. and Cosentino, M. James\*  
Department of Biology, Millersville University, Millersville, PA 17551  
Illuminex Corp., Millersville, PA

A new approach in the development of sensors that will detect extremely small concentrations of analytes such as hormones or cancer indicators in blood and other fluids very rapidly, is one that utilizes nanotechnology. In this approach, very small structures such as nanowire arrays need to be coated with active antibodies directed against the compounds to be analyzed. It is the purpose of these experiments to measure the degree of antibody attachment and the percent of those antibodies that are actually functional. That is, note the fraction of antibodies that really bind the antigen when they are attached to the wires. We have attached antibodies made against an indicator for ovarian cancer (CA 125) to nanowire arrays provided by Illuminex Corporation. These arrays are groups of parallel wires measuring approximately 80 nanometers by 120 nanometers attached to a glass substrate. Through a series of chemical reactions using MUA (11-mercaptoundecanoic acid) as spacer molecules, the antibodies were incubated with the nanowires and thus covalently attached. We then incubated these functionalized arrays with a fluorescent second antibody made against the attached antibody. The degree of fluorescence detected is proportional to the amount of antibody attached to the nanowires and was approximately  $9E-4$  ug of antibody per  $mm^2$  of nanowire array. In order to assess the percentage of the attached antibodies that will actually bind the cancer indicator, we incubated this antigen with the nanowire array to attach it to the antibody linked to the nanowires. Then, a third fluorescent antibody directed against the cancer marker (CA 125) was subsequently incubated with this mixture so as to attach to the CA 125 antigen that had been attached to the first antibody. High levels of fluorescence in this preparation indicated that a significant percentage of antibody that was attached in the initial reactions was indeed active and would bind the cancer marker readily.

## **6. Conservation Ethics of the Sale of Native/Non-Native Reptiles and Amphibians and the Potential Impact on Wild Populations**

Funck, Sarah and Wallace, J.R.\*

Department of Biology, Millersville University, Millersville, PA 17551

The demand for capture and trade of herpetofauna for use in the pet trade industry has increased in the past two decades due to availability of wild harvested animals, the discovery of captive breeding techniques, and the marketing of reptiles and amphibians at shows and expos. This project examines the potential impact of reptile shows on wild populations of herpetofauna with the following objectives: 1) characterizing the diversity of herpetofauna sold; 2) determining the percentage of wild-caught to captive-bred herpetofauna and; 3) surveying customers to identify demographics, herpetological interests, and the demand for specific herpetofauna. Vendor tables were assessed for species diversity and vendors questioned to determine the origin of animals sold. Customers were questioned about their opinions regarding conservation ethics on selling native and non-native animals as well as queried on their purchases to determine potential demand on specific taxa, demographics and purchases. Preliminary findings indicate that non-venomous snakes comprise 40% of the herpetofauna sold. Non-venomous snakes exhibit the greatest diversity, however 94% were captive-bred. However, lizards sold at these shows represented 30% of available herpetofauna, but also represented 56% of the total amount of wild-caught animals. Preliminary evidence suggests that lizards exhibit the highest risk of extirpation.

## **7. Why Cephalopods Have Large Brains: A Look at Body Patterning in *Octopus bimaculoides* and Learning in *Sepia officinalis***

Hanner, R.M. and Boal J.G.\*

Department of Biology, Millersville University, Millersville, PA 17551

Cephalopods are invertebrates with large brain to body size ratios and a complex central nervous system. Various lobes of the cephalopod brain function in controlling different behaviors. The reasons for the need for such a large, intricate nervous system are still being explored. In this study, two distinct experiments were conducted to see if these elaborate behaviors correlated with the complex cephalopod nervous system. Four octopuses, *Octopus bimaculoides*, were studied to determine if they showed specific body patterns or displayed them in a set sequence when preying on a common fiddler crab, *Uca pugilator*. Predation was broken down into three stages: Attention, Attack, and Retreat. No one body pattern was most common for the attention or attack stages. The disruptive pattern was observed the most during the retreat stage. Overall, the frequency of component changing and textural changing did not differ significantly between octopuses. The number of changes in components was greater in the arm area than the head area and greater in the head area than the mantle area. Twelve cuttlefish, *Sepia officinalis*, were studied to determine their conditional discrimination learning ability. The cuttlefish were presented with two tasks in which a particular clue was displayed in connection with a specific pattern surrounding the open exit of the maze. The cuttlefish were then given a third task in which the first two tasks were randomly presented. Three cuttlefish displayed conditional discrimination learning by demonstrating an association of each cue with its specific related pattern when the cues were randomly given, and exiting the maze through the correct door in under one minute. The association of body patterning with particular behaviors, the differences in component changes in different body areas, the rapidity of body pattern changes, and the

complex learning capabilities of cephalopods all reflect a correlation between complex cephalopod behavior and a complex brain.

## **8. Invasive Plants of the Millersville University Bush**

Hasapes, Kate S. and Hardy, Christopher R.\*

Department of Biology, Millersville University, Millersville, PA 17551

We documented the occurrence of 36 exotic plant species, primarily from specimens in fruit or flower, that occur in the Millersville University Bush. These species are not native to this geographic region and in particular the Bush woodland. They compete with the native species for habitat and niche space. Invasive species such as these can reduce biodiversity through their competitive displacement of native species. In the Bush, the majority of these species are found along the edge of the woodland. However, some particularly invasive species have made their way to the interior of the woodland and are continuing to spread.

## **9. Neomycin, Calcium Channels and Avoidance Behavior in *Paramecium caudata***

Klucsarits, Nicole and Reinking, Larry\*

Department of Biology, Millersville University, Millersville, PA 17551

In animals the nerve signal is comprised of an action potential, a wave of depolarization that cascades along a nerve cell. Action potentials can also occur in protozoans including *Paramecium*. In paramecia action potentials are initiated by the opening of calcium channels. These calcium gated action potentials cause ciliary reversal which in turn allows the paramecium to reverse direction and avoid obstructions. This study investigated the influence of neomycin on avoidance behavior in *Paramecium caudata*. Neomycin is an antibiotic that also is a calcium channel blocker in vertebrate tissue. Due to this action, it was hypothesized that neomycin should reduce avoidance behavior in *Paramecium*. Paramecia were exposed to a range of neomycin concentrations (100 - 1400 $\mu$ M, n=25 per concentration) and the frequency of avoidance behavior was observed under a stereomicroscope at 7x magnification. The frequency of behavior was compared to that in control solutions (zero neomycin). The results showed that as the concentration of the antibiotic increased the number of avoidance behaviors decreased. Therefore it can be concluded that neomycin does indeed affect avoidance behavior in *Paramecium caudata*.

## 10. Distribution and Abundance of Appendicularians in Coastal Virginia Waters

Kopala, Stephanie A. and Ambler, Julie W.\*

Department of Biology, Millersville University, Millersville, PA, 17551

The presence of appendicularians in coastal waters has an important impact on marine food webs. They form a gelatinous house around their body through which they use to filter small phytoplankton. The house is discarded up to ten times per day and becomes an important food source for many animals in the water column. We sampled a 40 mile long transect off the coast of Chincoteague, VA at eight stations during the months of July, August, and September in 2005. A vertical plankton tow with an 80 $\mu$ m mesh net was used to collect zooplankton samples and a Seabird 25 Sealogger CTD was used to obtain temperature profiles. We found the water column to be stratified with a strong thermocline typical of summer conditions. The appendicularian *Oikopleura dioica* occurred at all stations from July 20 to Sept. 2, with highest densities (300-600 per cubic meter) nearshore. *Appendicularia sicula* was present later (Aug. 4 to Sept. 2). Initially, *A. sicula* was only found 30-40 km offshore, but after Hurricane Irene, *A. sicula* was present at all stations on Aug. 18 and Sept. 2 with similar densities as *O. dioica*.

## 11. The Use of Scanning Electron Microscopy in the Assembly of Nano-Structures

McKinsey, Nichole (MU 2005); Habib, Youssef and Cosentino, M. James\*

Department of Biology, Millersville University and Illuminex Corp., Millersville, PA 17551

Nanotechnology involves technological development of devices that operate on the nanometer scale. The goal of this novel technology is to exploit the inherent molecular size of nano-structures since they have unique optical and electronic properties. Thus, nanotechnology has the potential to improve innumerable aspects of our everyday lives. In the manufacture of nano-structures (less than  $1 \times 10^{-7}$  m) it is essential to visualize the results of the process so that configuration, spacing, and cleanliness of the preparation can be observed and modified as needed. We have been using a scanning electron microscope (SEM) for this purpose to the advantage of producing consistent arrays of nanowires on a glass substrate. The nanowires we produce are made of silver (Ag) and gold (Au) which lend themselves well to SEM analysis. These arrays are used in the development of devices such as highly accurate sensors for medical diagnostics, chemical detection, photovoltaic structures for high performance portable generation of electricity, as well as thermal management systems. We demonstrate here, the usefulness of SEM to image and measure nanowire arrays under different fabrication processes. By noting the morphometric results of different manufacturing conditions, we can control the width, length, and spacing of these arrays so as to optimize their configuration for use in various applications. The images displayed here demonstrate the usefulness in monitoring nanostructure assembly using the scanning electron microscope.



## 12. Conditional Discrimination Learning in *Sepia officinalis* and *Octopus bimaculoides*

Simmons, Tiffany and Boal, Jean G.\*

Department of Biology, Millersville University, Millersville, PA 17551

Cephalopods are a unique organism to study due to their complex behavior. Cuttlefish, *Sepia officinalis*, and octopuses, *Octopus bimaculoides*, were used in two experiments to evaluate conditional discrimination learning; the subjects were taught the rule, if maze A, then response X, and if maze B, then response Y. Each of the two mazes used in this experiment had two exits, one open and one closed. The subjects were taught by training them to solve first one maze and then the other, and then presenting the mazes in random order. In the cuttlefish experiments, the open exit was indicated by the presence of either a rock (maze A) or algae (maze B). In the octopus experiment, the open exit was indicated by either two rocks (maze A) or a spotted towel (maze B). The time it took for the subjects to find the open exit, and the distance that they traveled, were measured in each series of trials. Experimental cuttlefish showed some evidence for conditional discrimination learning; however, no control group was included. Experimental octopuses performed no better than control octopuses; therefore, no evidence for any kind of learning was found. If these experiments were to be repeated, control subjects are clearly essential.

## 13. Biogeographical Studies in the Dayflower Genus, *Commelina* (Commelinaceae)

Sloat, Lindsey L. and Hardy, Christopher R.\*

Department of Biology, Millersville University, PA 17551

Of the 170 species of *Commelina*, 20 occur in the New World, of which nine occur in the United States. Only three of these nine U.S. species are native to the U.S.: these include (1) *Commelina virginica* (Virginia dayflower) distributed from southern Pennsylvania to Florida and Texas, (2) *C. erecta* (erect or slender dayflower) from the central and southeastern U.S. (to South America), and (3) *C. dianthifolia* (birdbill dayflower) from the southcentral U.S. and Mexico. Based on specimen data we obtained from the James C. Parks Herbarium, the U.S. National Herbarium, and the Fairchild Tropical Garden, we show that the six non-native species date in the U.S. from the 1830s through the 1980s. Not surprisingly, the earliest collections of non-native species come from ocean / sea ports and their surroundings. These introductions may have been mostly accidental, although at least one, *C. communis* (the Asiatic dayflower; found extensively in Lancaster and much of the country), seems to have been brought in as an ornamental. At least one non-native species, *C. benghalensis* brought into Hawaii and then Florida in the 1930s and 1940s, has gone onto to become an agricultural pest and is listed by the U.S.D.A. as a Noxious Weed.

#### **14. Floral Organogenesis in the Asiatic Dayflower, *Commelina communis* (Commelinaceae)**

Sloat, Lindsey L. and Hardy, Christopher R.\*  
Department of Biology, Millersville University, PA 17551

The plant family Commelinaceae has 650 species, including common house and garden plants such as spiderworts and the wandering-Jew. The Commelinaceae are well known for their diversity of floral forms, with those of the dayflower genus *Commelina* being among the most spectacular. Flowers of *Commelina* are typically 3-merous with 3 sepals, 3 petals, 3 stamens, 3 staminodes, and 3 carpels. The flowers are then divided into two functional halves, a lower (fertile) half that functions in the production of pollen and seeds, and an upper (sterile) half that functions in pollinator attraction through the production of bright yellow staminodes and large showy petals. Studies with the scanning electron microscope reveal that the development of the flowers begins normally, with the appearance of the sepals. The sepals continue to develop in a nearly normal fashion to fulfill their normal function of providing cover and protection of the floral bud. The coordinated development of the inner whorls of organs is, as far as is known, peculiar to *Commelina* and is possibly related to the division of the flower into fertile and sterile halves. Organs of the lower (fertile) half (i.e., the lower petal, 3 stamens, and two lower carpels) initiate and differentiate first and in a normal fashion. Organs of the upper (sterile) half (i.e., the upper 2 petals and 3 staminodes) are retarded in their development, initiating and differentiating much later than their lower-half counterparts. Although the upper half organs perform an equally important biological function (i.e., attraction), the essential aspects of their development (i.e., expansion and coloration), are apparently not needed until just before the flower opens. We hypothesize that development of the fertile, pollen-producing stamens and seed-producing carpels of the lower half is something less flexible and therefore proceeds normally.

#### **15. The Impact of the Meadow Vole, *Microtus pennsylvanicus*, on the Survival of Sapling Trees in a Riparian Restoration Project: Interim Report**

Starr, Scott and Zegers, David A. \*  
Department of Biology, Millersville University, Millersville, PA 17551

We are conducting a three-year study of the effect of the behavior of meadow voles on the survival of sapling trees in meadows undergoing a riparian restoration on the Yocom farm in Manor Township, Lancaster County, PA. In May 2005 a randomized block design experiment was initiated that involves six 7.62x7.62 m trapping grids. Each grid contains 23 Sherman live traps placed in or adjacent to vole runways. Three grids were surrounded by fencing to exclude meadow voles and three remained unfenced. Each grid area was planted with 16 sapling trees (4 each of white oak, river birch, green ash and sweet gum); each seedling was surrounded by a 0.60m tall plastic tube. After live trapping and removing voles from the enclosure grids vole density on those plots was significantly lower than that on the control grids. At the end of the first year overall survival of saplings (all species), however, was uniformly high on all six plots, and no impact by meadow voles was apparent. There was, however, a non-significant negative correlation between vole density and the survival oaks. The next two years should provide definitive data concerning the impact of meadow voles on the survival of all four species of trees.

## 16. Illustration of Three New Plant Species in the Spiderwort Family, Commelinaceae

Stoltzfus, Zel; Faden, Robert B. and Hardy, Christopher, R.\*  
Department of Biology, Millersville University, PA 17551

As part of his doctoral research, Dr. Hardy documented the occurrence of three undescribed plant species in the spiderwort family, Commelinaceae. These species are unnamed here simply because they do not yet have names. In preparation for their published descriptions, one of us (Zel Stoltzfus) has been illustrating their habits and flowers, and these illustrations will serve to help identify the species in the field, as well as to distinguish them from previously known species in the family. One species occurs in Amazonian Peru and is distinguished by other members of its genus, *Geogenanthus*, by its unusually short pedicels and large, highly branched inflorescences. Two additional species occur in the low and middle elevations west of the Andes in Ecuador and Colombia. They are both very closely related and are distinguished from the others by, among other characteristics, their ribbed leaves. Although it is typical in *Geogenanthus* to have bearded (hairy) upper stamens, one of these western species is distinguished by its glabrous stamen filaments. These illustrations will be submitted for publication alongside the formal descriptions of these species in an upcoming issue of the journal *Systematic Botany*.

## 17. Identification of Genes Involved in Regulating *HOT1*-Stimulated Recombination in *Saccharomyces cerevisiae*

Sutcliffe, Erin and Hepfer, Carol E.\*  
Department of Biology, Millersville University, Millersville, PA 17551

Genetic recombination is an essential process occurring in the cells of all living organisms. By enabling the combination of genes in an organism's offspring to differ from the combination in their parents, recombination provides opportunities for natural selection. Recombination also maintains the genome by repairing damaged genes. Deciphering mechanisms and identifying proteins involved in recombination should increase our understanding of cancer and aging. Yeast can be used very effectively as a model to better understand mechanisms of genetic recombination in all eukaryotic organisms, including humans. Many processes in yeast are very similar to those in humans, but yeast cells grow more rapidly and their genes can be manipulated more easily. In yeast, the *DEG1* gene is essential for normal growth at elevated temperatures and for high rates of mitotic recombination that maintain repetitive ribosomal DNA sequences. Mutations in *DEG1* impede cell growth at elevated temperatures and specifically reduce recombination that normally is stimulated by the hotspot known as *HOT1*. Since the product of *DEG1* is a pseudouridyl synthase that modifies transfer RNA, its impact on *HOT1*-stimulated recombination probably results from the altered synthesis of other proteins more directly involved in the process. The goal of this project is to identify some of those proteins and to determine their roles in recombination. If mutations in *DEG1* reduce *HOT1*-stimulated recombination and prevent growth at high temperatures by reducing the activity of certain proteins, then restoring the expression of those proteins should suppress mutant phenotypes. To find genes encoding potential suppressor proteins, temperature sensitive *deg1* cells were transformed with a collection of normal yeast genes carried on vectors that increase their expression. Transformed cells able to grow at high temperatures were then analyzed to identify suppressor genes. Candidate suppressors will be evaluated to determine if they play an important role in genetic recombination.

# Chemistry

## 18. Using the Effects of Antibiotics on Bacterial Growth to Demonstrate Pharmaceutical Concepts

Kahler, Kirsten and Miller, Aimee L.\*

Department of Chemistry, Millersville University, Millersville, PA 17551

The pharmaceutical field is constantly expanding, and many biochemists pursue related careers. We are developing a lab that explores pharmacology concepts, including dose response and drug resistance. Dose response was tested by introducing different amounts of carbenicillin to *E. coli* and analyzing bacterial growth using a halo test. Treating the *E. coli* with 0.25 to 5 mg/ml carbenicillin cleared corresponding halos diameters of 8 to 29mm. No halo formed without drug application. Students will use the diameter of the halos to generate a dose response curve. We are currently developing a second study of the ability of an ampicillin resistance gene ( $Ap^R$ ) to restore *E. coli* growth in the presence of antibiotics in different antibiotic classes with varying chemical structures. The *E.coli* were transformed with a plasmid (pRS313) that carries a copy of the ampicillin resistance gene. So far, the effect of two antibiotics, carbenicillin and G418, have been tested against *E. coli* with the ampicillin resistance gene. Since ampicillin and carbenicillin are in the same family of antibiotics,  $Ap^R$  should confer resistance to carbenicillin. G418, also known as geneticin, was used because it has a different chemical structure and does not belong to the penicillin family of antibiotics. Thus,  $Ap^R$  was not expected to rescue growth in the presence of G418, and clearing of the bacteria should still occur. Initial experimental data confirmed the predicted effects of carbenicillin and G418 on *E. coli* growth. An expansion to this study will be to test other antibiotics from the penicillin and aminoglycoside classes against the *E.coli* with  $Ap^R$ . Furthermore, growth of *E.coli* with  $Ap^R$  could also be tested in the presence of another class of antibiotics.

## 19. Production of Double Mutant Strains in the Inositol Pathway of Yeast

Meyers, Jodi L. <sup>1</sup>; Johnson, Sylvia L. <sup>2</sup>; Wentz, Susan R. <sup>2</sup> and Miller, Aimee L. <sup>1\*</sup>

1: Department of Chemistry, Millersville University, Millersville, PA 17551; 2: Department of Cell and Developmental Biology, Vanderbilt University Medical Center, Nashville, TN 37232

Inositol hexakisphosphate ( $IP_6$ ) is produced in yeast by the *IPK1* gene product, inositol polyphosphate kinase 1 (Ipk1). A synthetic lethal screen in *saccharomyces cerevisiae* identified a potential interaction with the *ALR1* gene which encodes a  $Mg^{2+}$  transporter. The first goal of this project is to combine null ( $\Delta$ ) mutations of these two genes by mating haploid *ipk1* $\Delta$  and *alr1* $\Delta$  strains. The diploid strain will be manually dissected to isolate the *ipk1* $\Delta$ /*alr1* $\Delta$  double mutant haploid strain. This strain will be tested for viability to confirm the synthetic lethality between *ipk1* $\Delta$  and *alr1* $\Delta$ . Since no functional relationship is known for these two genes, a second goal of this project is to similarly combine *alr1* $\Delta$  with two additional mutations, *ipk2* $\Delta$  and *plc1* $\Delta$ . Ipk2 and Plc1 proteins play roles upstream of Ipk1 in the  $IP_6$  production pathway. Results from this project should indicate whether  $Mg^{2+}$  transport might be related to  $IP_6$  production.

# Computer Science

## 20. Research into Developing 3D Game Programming Toolkits Using OpenGL™ and DirectX™

Billman, Chad; Bush, Matthew; Harris, Matthew; Hollinger, Jonathan; Land, Greg; Waldon, Steve; Webster, Roger\* and Zoppetti, Gary\*  
Department of Computer Science, Millersville University, Millersville PA 17551

Programming a 3D video game or graphical application using the OpenGL or DirectX API's can be daunting. To facilitate development, we have created object-oriented toolkits for OpenGL and DirectX that abstract away many of the low-level details and provide enhanced functionality. For example, both of the MU-developed toolkits (MUopengl Toolkit and MUDirectX Toolkit) provide easy-to-use objects such as camera; moveable with MoveForward(), MoveBackward(), MoveX(), MoveY(), MoveZ(), Pitch(), Roll(), and Yaw(); positional 3D sound; 3D Studio model loading; skyboxes; billboards; animated TGA textures with alpha channel support; Cal3D animated characters with quaternion interpolation; MD3 Quake-animated characters; explosions; particle systems for smoke, fire, fog, and simple fluid dynamics; weapons; and collision detection. The toolkits also have an extensive library of vector and matrix operations. Additionally, the networking classes simplify packet sending so network games can be developed with up to 8 people playing highly interactive, fast, 3D first person shooter games. The OpenGL toolkit has been used successfully for over five years in the undergraduate courses CS375 3D Graphics and CS475 Game Development and Computer Animation. These toolkits allow students to focus on programming the game play, computer animation, artificial intelligence, and overall compelling 3D virtual world interaction. The success of the OpenGL toolkit inspired the creation of a complementary toolkit using DirectX 9. Demos of the games and more information can be found at

<http://cs.millersville.edu/~webster/gametechnologytrack/resources.html>.

## 21. Simulating the Continuous Curvilinear Capsulorhexis Procedure During Cataract Surgery

Harris, Matthew<sup>1</sup>; Billman, Chad<sup>1</sup>; Bush, Matthew<sup>1</sup>; Hollinger, Jonathan<sup>1</sup>; Land, Greg<sup>1</sup>; Waldon, Steve<sup>1</sup>; Webster, Roger\*<sup>1</sup>; Sassani, Joseph<sup>2</sup> and Zoppetti, Gary\*<sup>1</sup>

<sup>1</sup>Department of Computer Science, Caputo Hall, Millersville University, Millersville, PA. 17551

<sup>2</sup>Department of Ophthalmology, Penn State University College of Medicine, Milton S. Hershey Medical Center, Hershey, PA 17033

This paper describes a technique for simulating the capsulorhexis procedure during cataract surgery on the EYESI™ system. The continuous curvilinear capsulorhexis technique can be a difficult procedure for beginning ophthalmology surgeons. In the initial phase of tearing the tissue, the tear vector is tangential to the circumference of the tear circle. However, without the proper re-grasping of the flap of torn tissue close to the tear point, the tear vector angle quickly runs downhill possibly causing severe damage to the tissue. Novice surgeons tend to try to complete the capsulorhexis without the time consuming re-grasping of the tissue flap. Other factors such as anterior bowing of the lens diaphragm, patient age, and shallow anterior chambers add to the problematic nature of the procedure. The tissue area is modeled as a curvilinear mesh of nodes and springs. Deformation is accomplished via a physically based particle model utilizing a heuristic algorithm to constrain the deformation calculations to the

locality of the tear area to speed up computations. The training software alerts the user of any potential tear problems before they occur thus instructing the novice surgeon. The EYESI™ hardware system (from VRMagic GmbH) provides the user with stereoscopic images thus providing 3D viewing. Our capsulorhexis simulator software models a number of tear problems and anomalies to provide a useful training environment without the dangers of using live patients.

## **22. Networking Infrastructure Documentation Management System Utilizing Asynchronous Web Technologies**

Hobbs, Dwight and Hutchens, David \*

Department of Computer Science, Millersville University, Millersville, PA 17551

We built a web application to organize and manage the details of the MU campus network infrastructure. The software is written primarily to track physical connections within a given building and to answer questions regarding the endpoints of a given connection. Physical connection information is useful for localizing network performance issues and isolating excessive bandwidth usage due to virus or illicit activity.

The application was written using Asynchronous Javascript and XML (AJAX) technology for a seamless user experience, and the web application framework Ruby on Rails, written in the C-like programming language Ruby. Ruby on Rails was chosen based on its reputation for ease and speed of implementation and ease of maintainability due to simple syntax and consistent conventions. Overall, this project demonstrates the reputation is deserved. On one of occasion, the desired functionality proved difficult to achieve. We used an alternative, and on reflection perhaps better, interface design to work around this difficulty.

## **23. DirectXynth: Sound Synthesis with C#.NET and DirectSound**

Johnson, Phillip A. and Zoppetti, Gary M.\*

Department of Computer Science, Millersville University, Millersville, PA 17551

This research investigated the sound synthesis possibilities of the PC using the C# language, the .NET framework, and the DirectSound application programming interface. Several software synthesizers already run under Windows, but they are often expensive and have limited extensibility. DirectXynth offers not only a free alternative, but also a unique, customizable alternative. The premise of the program is that nearly all aspects of a sound, or several played simultaneously, may be controlled by clicking and dragging the mouse (or better yet, a stylus) across an X/Y plane. This allows smooth pitch shifting between notes, among other things. The mouse coordinates are then used to update settings such as frequency, volume, and pan. These settings are managed by a controller class. Each controller object contains a base value corresponding to the origin, a range, and an axis designator. Any numerical setting in your program can be attached to a controller. This allows for simple extensions to the program, like the addition of reverb or chorus effects.

One of the more unique features of DirectXynth is the variable arpeggiator. It is an effect of the student's design. Any value of the arpeggio can be attached to a controller. For example, you could have the X-axis represent a range of 0 to 20 different notes. When you click on the grid, DirectXynth will iterate through all these notes using the frequency multiplier. A frequency multiplier of 2.0 will iterate through octaves, while a multiplier of 1.25 will iterate through

fourths. This allows the arpeggio to change dynamically, which can result in complex arrangements, especially when multiple sounds are combined. DirectXynth employs 650 lines of code, and leverages the expressiveness of the C# language, the rich .NET class library, and the Visual Studio GUI builder.

## **24. The Portable Personal Profile Project**

Shearer, Shane; Liffick, Blaise\* and Zoppetti, Gary\*  
Department of Computer Science, Millersville University, Millersville, PA 17551

The goal of the Portable Personal Profile (PPP) project is to develop a program that will allow users to carry their personal Windows® settings with them when they use a different computer. This will be accomplished using a special USB flash drive device and auto-run program. This software will (1) capture a user's settings from a source machine (e.g. their home computer), store those settings on a flash drive, (2) reset the target machine's control settings by installing those captured in the first step, and (3) restore the target machine's original settings when the user discontinues use of the target machine. Such a system would be especially useful for disabled users, who may need special display, keyboard, mouse, etc., settings in order to use a system effectively.

## **25. Developing a Java 2 Platform, Enterprise Edition Web Application**

Shearer, Shane A. and Zoppetti, Gary M.\*  
Department of Computer Science, Millersville University, Millersville, PA 17551

The Java 2 Platform, Enterprise Edition (J2EE), is a popular architecture highly valued by employers for creating distributed enterprise applications and web services. We used this framework, including Java Servlets, JavaServer Pages (JSP), and Enterprise JavaBeans (EJB) components, to develop a distributed web application to maintain a database of collectibles.

By using only a web browser (even on a PDA), a user can access the application, receive dynamically generated web content, and update a database. The application uses several database tables to store collectibles, such as a table of movies (title, director, year, genre, format, etc.), a table for each category or format (HD-DVD, DVD, VHS), and a table mapping movies to formats. Five web pages were created using JSP, HTML, and Servlets: a page to welcome the user, add new items, add new categories, generate reports, and edit existing items. Session and Entity Beans perform the business logic (calculations) and interface with the database server. These beans execute on a server, offering better reliability, security, and application performance than client machines can offer.

# Earth Sciences

## **26. Garnet Compositions Producing Protective-Surface Coatings Identified Using the Pilling-Bedworth Rule**

Anderson, Diane and Price, Jason R.\*

Department of Earth Sciences, Millersville University, Millersville, Pa 17551

Garnet compositions that produce a protective-surface coating can be found by applying the Pilling-Bedworth Rule. Application of the Pilling-Bedworth Rule to each of 251 published unique garnet chemical compositions found that only almandine garnet compositions have sufficient iron and aluminum stoichiometries to produce a protective-surface coating of goethite and gibbsite.

The chemical compositions of three almandine garnet samples from western North Carolina and one almandine garnet sample from southern Lancaster County, Pennsylvania were obtained. Microscopic observations reveal that the garnets from western North Carolina form protective-surface coatings while the ones in southern Lancaster County, Pennsylvania do not. The values obtained by applying the Pilling-Bedworth rule to all four garnets shows that none of them should have produced a protective-surface coating for their chemical compositions.

Proper secondary mineral characterization may account for the difference between the theoretical and observed results for the North Carolina garnets. Secondary minerals goethite and gibbsite may not be the only secondary minerals involved in the formation of the protective-surface coatings.

## **27. Lightning Research/Climatology for Southeastern Pennsylvania and Correlation Between Lightning Density and Terrain Elevation**

Cipriani, James; Schreiber, Kathleen and DeCaria, Alex \*

Department of Earth Sciences, Millersville University, Millersville, PA 17551

We are analyzing observed lightning strike data for southeastern Pennsylvania from 1995 through 2001. The data contains the location, strength, polarity, and date of each strike. Monthly average distributions of number of lightning strikes and percentage of positive lightning strikes (strikes which lower a positive charge to the ground) for 17 counties were created. We've confirmed the results from a study by a prior student (Mike Babij) of a slight negative yet statistically significant correlation between elevation and lightning strike density for Southeastern Pennsylvania. We have also tested the monthly lightning strike distributions from the 17 counties for homogeneity, and found that they are not homogenous. Future work will attempt to group the counties having similar monthly distributions with the goal of identifying common geographical factors that may influence the monthly lightning distribution.



## **28. A One-Dimensional Shallow-Water Model to Simulate the Adjustment of a Rotating Fluid**

Eipper, Daniel and DeCaria, Alex\*

Department of Earth Sciences, Millersville University, Millersville, PA 17551

We developed a one-dimensional shallow-water model to simulate the adjustment of a constant density fluid in a rotating reference frame. The model is programmed in the Interactive Data Language (IDL) and uses standard finite-difference techniques. The model includes radiative boundary conditions to allow waves to traverse out of the model domain with minimal reflection. The model correctly simulates the geostrophic adjustment process, resulting in small-scale disturbances adjusting the water level to the initial velocity field and large-scale disturbances adjusting the velocity field to the initial water level. The ultimate goal is to have an easy-to-use model that can be used in a classroom setting to demonstrate important large-scale adjustment process that occur in the atmosphere and oceans. We will also be creating a version of the model using cylindrical coordinates to simulate adjustment in axisymmetric circulations, with the goal of exploring anomalous flows that are mathematically possible but rarely observed in the atmosphere and oceans.

## **29. Present-Day Physical Erosion Rate for Brubaker Run**

McKinney, Patrick and Price, Jason R.\*

Department of Earth Sciences, Millersville University, Millersville, PA 17551

Using the methods of dilution gauging and sediment separation, we find that Brubaker Run has a considerably lower present-day physical erosion rate than the predicted long-term average. The present-day measured rate is approximately 17,000 g/ha/yr, while the long-term average is approximately 140,000 g/ha/yr. Discharge and erosion rate were found to be inversely proportional. These observations lead us to believe that physical erosion at Brubaker Run has occurred as infrequent, cataclysmic events. These large-magnitude events likely occurred between approximately 30,000 and 14,000 years ago when the region experienced a cold, stormy, and unstable climate. In addition, when Brubaker Run is compared to other streams within Lancaster County, Pennsylvania, it was determined that streams located in areas of high agricultural activity appear to carry more suspended sediment than those located in areas of low agricultural activity. The Brubaker Run watershed is relatively undisturbed and has a measured physical erosion rate of approximately 4.9 ton/mi<sup>2</sup>/yr. In contrast, more agricultural watersheds in Lancaster County have erosion rates ranging from approximately 300-1,000 ton/mi<sup>2</sup>/yr. These findings demonstrate the strong influence of land-use on stream suspended sediment loads in agricultural regions.

### **30. Identifying Anthropogenic Contribution of Potassium in Streams Developed on Carbonate Bedrock**

Runkle, Timothy and Price, Jason R.\*

Department of Earth Sciences, Millersville University, Millersville, PA 17551

Samples of stream water were collected in order to assess potassium concentration in the Conestoga and Little Conestoga watersheds. Because these streams flow over carbonate bedrock, any potassium found in the stream water can be attributed to anthropogenic contributions. It was hypothesized that golf courses are a point source of potassium. Potassium levels rise as the streams enter the surrounding area of Lancaster City and generally dissipate as they leave. Point sources of potassium could not be found. It may be hypothesized that the residential use of fertilizer is the non-point source of potassium, however identifying the exact sources and their individual contributions will require further study.

### **31. Atmospheric Deposition: MU Earth Sciences Partners in NADP/NTN/MDN Network**

Sutcliffe, Mark; Potter, Brittany; Wise, Lori and Clark, Richard\*

Department of Earth Sciences, Millersville University, Millersville, PA 17551

The National Atmospheric Deposition Program's National Trends Network and Mercury Deposition Network (NADP/NTN/MDN) is nationwide network of 250 precipitation monitoring sites, of which 90 sites also collect samples for trace metals analysis. The network is a cooperative effort between many different groups, including the State Agricultural Experiment Stations, U.S. Geological Survey, U.S. Department of Agriculture, and numerous other governmental and private entities.

Over the past century acid rain and high environmental mercury levels have been shown to deleteriously affect lives and ecosystems. Air contaminants can originate from countless point source and extended sources areas, become entrained into air parcels advected by the source, and are later removed from the atmosphere by either dry or wet deposition processes. The NADP network is interested in the concentrations of ions and trace metals that rain-out.

A precipitation collection field site (PA47) has been established about 1.8 km west of Millersville through long-term funding from the PA-DEP to continuously monitor liquid water equivalent (rain or melted snow). Students have been dutifully collecting sample every Tuesday since November 2002 in accordance with NADP collection and quality assurance protocols.

Once the samples are collected, and after preliminary analysis at Millersville University, they are sent to national labs for detailed analysis of the following ions:  $\text{Ca}^{+2}$ ,  $\text{Mg}^{+2}$ ,  $\text{K}^+$ ,  $\text{Na}^+$ ,  $\text{NH}_4^+$ ,  $\text{NO}_3^-$ ,  $\text{Cl}^-$ ,  $\text{SO}_4^{-2}$ , and pH, and the trace metals, Hg.

This study will focus on the PA47 (Millersville) NADP/NTN and MDN databases and their context within the national database. Many factors affect the concentrations of ions and trace metals at a particular site, not the least of which is the meteorology and the amount of precipitation deposited from passing weather systems. Consequently, average monthly and annual concentrations can be very different from one period to the next. Overall, PA47 exhibits concentrations of ions and trace metals that are similar to sites in the eastern U.S. Since 1985,  $\text{SO}_4$  and  $\text{NO}_3$  show a slight decrease probably due to regulations that limits their emissions at the source. Ammonium as  $\text{NH}_4^+$  shows no long term trend but varies between 2-4 kg/ha, while total inorganic nitrogen (N) varies between 4-7 kg/ha over the same period. The poster will expand

upon the spatial and temporal trends for each ion and trace metal and show connections with the seasonal meteorology over U.S.

Millersville University Department of Sciences has committed to a five year sample collection program (2002-2007), with the option for a five year renewal, which we are likely to do. Through the continuing efforts of site monitors, sponsors, and NADP/NTN/MDN, policy makers and regulators will have a robust database for informed decisions on the current state of atmospheric pollutants and the consequences of policy decisions.

### **32. Petrographic Studies of the Precambrian Honey Brook Upland**

Tarbert, Kevin and Marquez, Lynn L.\*

Department of Earth Sciences, Millersville University, Millersville PA 17551

The Honey Brook Upland located in Lancaster and Chester counties consists of a one billion year old metamorphic complex formed during the formation of the supercontinent Rodinia. Approximately 500 million years later, tectonic uplift during the formation of Pangea and subsequent erosion, exposed these rocks at the Earth's surface. These formations provide a rare glimpse into Precambrian tectonics as they constitute approximately 20%, by area, of all exposed rocks on the Earth's surface.

Field investigations indicate that at least four different gneisses are found within the Honey Brook Upland. Petrographic studies reveal the mineral assemblages present in the gneisses. These assemblages help to determine not only the pressure and temperature conditions of metamorphism but also the composition of the parent rocks. Initial petrographic results of two different gneisses show distinctly different compositions which ultimately relate to differences in parent rocks. Felsic and intermediate gneisses consist predominantly of Plagioclase and K-Spar (35-50%); quartz (3-35%); and micas typically muscovite and biotite (1-45%). Accessory minerals in these gneisses include epidote (3-35%), garnet (1-10%), calcite (5%), and chlorite (5%). Another less quartz rich gneiss includes higher grade metamorphic minerals such as: Hornblende (35%) and Augite (20%). Continued investigations will determine the relationships between these rocks and the processes by which they form.

### **33. Linked Environments for Atmospheric Discovery: The Role of Undergraduates in a Information Technology Research Collaborative**

Warren, Christopher; Williams, Michael; Yorks, John; Yalda S.\* and Clark, R.\*

Department of Earth Sciences (Meteorology), Millersville University of Pennsylvania, Millersville, PA 17551

As a collaborative partner in Linked Environments for Atmospheric Discovery (LEAD), Millersville University is responsible for the evaluation and assessment of LEAD prototypes, and the development and dissemination of educational materials and services to the wider education community. Toward this effort, Millersville University is collaborating with other LEAD partner institutions, as well as with local high schools in extending several existing tools such as Unidata's Integrated Data Viewer (IDV) and NASA JPL's SWEET ontology for LEAD educational initiatives. Undergraduate students at Millersville have been involved in developing interactive modules and other learning materials around the IDV. Undergraduate students have developed an IDV beginner's tutorial that is specifically designed for pre-college teacher and student users. In addition, they have created IDV bundles that serve as a basis for the visualizations within the LEAD-To-Learn education modules. These modules allow students to

interact with and visualize output from the NAM and WRF numerical models, and other data types, while learning through discovery related meteorological concepts. Undergraduate students have also been involved in a significant extension of the Semantic Web for Earth and Environmental Terminology (SWEET) ontology developed at NASA JPL to include quantities of relevance to mesoscale meteorology. Over 560 new quantities have been added, tripling the ontology vocabulary, and this number is likely to reach 1000. Another key enhancement of the Millersville effort is the addition of a glossary for the LEAD ontology. The SWEET-LEAD ontology will be wrapped as a Web Service at the University of Alabama-Huntsville, and will be accessible via the LEAD portal for query, info-mining, and resource cataloging, and is an essential component in the development of a dynamically adaptive learning environment for students and teachers. Finally, Millersville undergraduates worked extensively with Howard University to develop educational supplemental materials for Howard's Weather Camp that took place in July 10-29, 2005. Undergraduate students at Millersville have developed specific IDV bundles that are utilized to enhance the instructional material, but were also used by Weather Camp 2005 students for research projects and further discovery.

## Mathematics

### 34. The Generalized Brachistochrone Problem

Gemmer, John A.; Nolan, Michael\* and Umble, Ron\*

Departments of Mathematics and Physics, Millersville University, Millersville, PA 17551

Consider a frictionless surface  $S$  in a gravitational field that need not be uniform. Given two points  $A$  and  $B$  on  $S$ , find the curve traced out by a particle that is released from  $A$  and travels to  $B$  in the shortest time. This leads directly to the Euler-Lagrange equation. On simple surfaces such as surfaces of revolution in uniform or inverse square fields, the Euler-Lagrange equation is separable and solvable.

# Physics

## 35. Light Pressure on a Diaphragm

Benway, Tanya and Dooley, J.W.\*

Physics Department, Millersville University, Millersville, PA 17551

An aluminum foil diaphragm, stretched over a small embroidery hoop is deflected when light from a camera flash lamp strikes it. We have observed the deflection at atmospheric pressure and in a vacuum, finding evidence for both impulsive and thermal components to the deflection. The impulsive response has a rise time less than 50 microseconds, and a time duration of about 5 milliseconds, on the order of the duration of the flash. In vacuum, this is followed by ringing at the natural “drumhead” frequency of the diaphragm for several hundred milliseconds. The presumed thermal response is a relaxation to the original state which takes times on the order of 10 seconds.

## 36. Surface Plasmon Resonance Observation

Saint John, David; Gallek, Leah and Dushkina, Natalia\*

Department of Physics, Millersville University, Millersville, Pa 17551

A table-top apparatus was constructed to create and observe an optical phenomenon known as "Surface Plasmon Resonance" (SPR). Surface plasmons are excited when perpendicularly polarized light from a He-Ne laser is incident on a glass-metal interface at some critical angle, and this is observed as a drastic minimum in the intensity of the light reflected off the sample surface. Our apparatus allows for the measurement of the characteristic reflectivity of any suitable thin film sample, which can be used to determine the thickness and optical parameters of the thin film; including indices of refraction and absorption. The current batch of test samples include thin silver films, nano-porous gold films and polypyrrole-on-silver films, all deposited onto glass plates. Theoretical fitting requires the preliminary description of silver thin films, which we will later use as a basis for investigating nano-structured SiO<sub>2</sub> films.

Additionally, our project was designed with the interests of a future optics course in mind. There are a limited number of physics demonstrations which can affordably illustrate fundamental principles to students. A table-top SPR apparatus involves familiarity with solid-state lasers, lenses, polarization, Snell's law, and Electromagnetic fields; all of which are important aspects of the forthcoming optics curriculum.

# Index of Authors

<u>Name</u>	<u>Abstract Number</u>
Ambler, Julie*	3, 10
Anderson, Diane	26
Benway, Tanya	35
Billman, Chad	20, 21
Blakeslee, Carrie	1
Boal, Jean*	1, 7, 12
Bush, Matthew	20, 21
Cawley, Michael	2
Cipriani, James	27
Clark, Richard*	31, 33
Cosentino, James*	5, 11
Day, Melissa	3
DeCaria, Alex*	27, 28
DiBartolomeis, Susan*	4
DiStefano, Jennifer	4
Dooley, John*	35
Dower, Nicholas	5
Dushkina, Natalia*	36
Eipper, Daniel	28
Faden, Robert	16
Funck, Sarah	6
Gallek, Leah	36
Gemmer, John	34
Habib, Youssef	11
Hanner, Rachel	7
Hardy, Christopher*	8, 13, 14, 16
Harris, Matthew	20, 21,
Hasapes, Kate	8
Hepfer, Carol*	17
Hobbs, Dwight	22
Hollinger, Jonathan	20, 21
Hutchens, David*	22
Johnson, Phillip	23
Johnson, Sylvia	19
Kahler, Kirsten	18
Klucsarits, Nicole	9
Kopala, Stephanie	10
Land, Greg	20, 21

<u>Name</u>	<u>Abstract Number</u>
Liffick, Blaise* .....	24
Marquez, Lynn* .....	32
McKinney, Patrick .....	29
McKinsey, Nicole .....	11
Meyers, Jodi .....	19
Miller, Aimee* .....	18, 19
Mone, James* .....	4
Nolan, Michael* .....	34
Pelliccia, Jose .....	5
Potter, Brittany .....	31
Price, Jason* .....	26, 29, 30
Reinking, Larry* .....	9
Runkle, Timothy .....	30
Saint John, David .....	36
Sassani, Joseph .....	21
Schreiber, Kathleen .....	27
Shearer, Shane .....	24, 25
Simmons, Tiffany .....	12
Sloat, Lindsey .....	13, 14
Starr, Scott .....	15
Stoltzfus, Zel .....	16
Sutcliffe, Erin .....	17
Sutcliffe, Mark .....	31
Swords, John .....	2
Tarbert, Kevin .....	32
Umble, Ron* .....	34
Waldon, Steve .....	20, 21
Wallace, John* .....	6
Warren, Christopher .....	33
Webster, Roger* .....	20, 21
Wente, Susan .....	19
Williams, Michael .....	33
Wise, Lori .....	31
Yalda, Sepi* .....	33
Yocom, Daniel* .....	2
Yorks, John .....	33
Zegers, David* .....	15
Zoppetti, Gary* .....	20, 21, 23, 24, 25

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