

## ABSTRACTS OF PAPERS PRESENTED AT THE 107TH ANNUAL MEETING

## BOTANY SECTION

Louis Schibig, Chair

ALUMINUM AND CADMIUM AS STRESSORS ON *GLYCINE MAX*. **E. L. Myles, Lisa Griggs\*, Deborah Long and C. Caudle, Tennessee State University, Nashville, Tennessee.** Metal toxicity can reduce the vigor and yield of crop plants. Water-borne and air-borne cadmium can cause increased concentrations of cadmium in the soil. Fertilization with sewage sludge can greatly increase the soil cadmium and ultimately affect the growth and reproduction of *Glycine max* (soybeans). Aluminum is abundant in soils and generally is not a problem for soybean crops. When the soil becomes acid, transport of aluminum into the roots is easier. The aluminum will then become disruptive to the plant's normal metabolic processes. In soybeans, the problem increases because of acidity and aluminum toxicity. Among the various cultivars of soybeans, there may exist genetic diversity that will make some plants more or less tolerant to metal toxicity. The present study examined three cultivars (Forrest, Hutcheson, and Tomahomare) for their tolerance to aluminum and cadmium. Germination of seeds for each cultivar was in medium containing 0.0 mM (control), pH 4.5, 7.0 mM and 14.0 mM aluminum sulfate. In another set of experiments, the medium contained 0.0 mM (control), 0.5 mM, and 1.0 mM cadmium sulfate. The exposure period was seven days. The three measurements taken were of the hypocotyl, root and total lengths to determine the effect of acidity, aluminum and cadmium on the growth and germination of soybeans. All three cultivars showed a relatively high tolerance to acid (pH 4.5). However, cultivar Tomahomare had a higher tolerance to the metals and Hutcheson was more sensitive.

CHLOROSIS IN AMERICAN GINSENG (*PANAX QUINQUEFOLIUM*) RELATED TO POSSIBLE MICRO-NUTRIENT DEFICIENCIES. **Kent Gallaher and Raymond N. Gallaher, Lipscomb University, Nashville, Tennessee and University of Florida, Gainesville, Florida.** Tissue samples from both chlorotic and healthy three year old plants were collected in May 1997 from a commercial grower in Lawrence Co., Tennessee. Soil samples associated with each plant type also were collected at that time. Nitrogen analysis was conducted by a variant of the Kjeldahl method. Concentrations of Ca, Mg, Cu, Fe, Mn, and Zn were determined by atomic adsorption spectrophotometry, and K and Na concentrations were determined by atomic emission spectrophotometry. Tissue and soil analysis were compared for healthy and chlorotic three year old plants. Soil pH from healthy plants was 6.5 while pH from chlorotic plants was 7.4. Soil concentrations of Ca and Mg were 60% to 100% greater in chlorotic areas. Root tissue data revealed that chlorotic plants had much lower concentrations of Cu, Fe, Zn and Mn than did healthy plants. When soil pH exceeds 7.0, Cu, Fe, Zn, and Mn availability rapidly decreases. High soil concentrations of Ca and Mg indicate over liming of the soil prior to planting. Thus, observed chlorosis

could be the result of a Cu, Fe, Zn, or Mn deficiency or a deficiency in a combination of some or all of these micro-nutrients.

CADMIUM AND ZINC UPTAKE AND TRANSLOCATION IN THE PASTURE GRASS (*FESTUCA ARUNDINACEAE*). **Kristie L. Pinkerton\* and Kent Gallaher, Lipscomb University, Nashville, Tennessee.** The application of bio-solids on pasture land is a common practice of many municipalities. In this study, *Festuca arundinaceae* was grown in soil amended with varying concentrations (0, 1, 10, 25, 50, and 100  $\mu\text{g/g}$ ) of Cd as  $\text{Cd}(\text{SO}_4)_2$  or Zn as  $\text{Zn}(\text{SO}_4)_2$ . Plants were allowed to grow for 27 days in a commercial "topsoil." Plants were then harvested, washed, and divided into root and shoot sections. Samples were analyzed for Cd and Zn concentration by atomic absorption spectrophotometry. Plant uptake of both metals was directly influenced by soil concentration. Little translocation of Cd was observed, with 75.6% of total Cd being sequestered in root tissue. Zinc translocation data revealed 55.5% of total Zn accumulation occurred in the shoot tissue. Zinc translocation data revealed 55.5% of total Zn accumulation occurred in the shoot tissue. When whole plant dry matter data were standardized for content, Cd and Zn content at the highest application rates was  $\leq 40 \text{ g ha}^{-1}$ . Thus, sludge containing Zn or Cd within this range of concentrations might be safe for land application.

A COMPARATIVE STUDY OF THREE BOTTOM LAND HARDWOOD FORESTS, LOWER CUMBERLAND RIVER, TENNESSEE AND KENTUCKY. **Edward W. Chester, Joe Schibig and Frank Dodson, Austin Peay State University, Clarksville, Tennessee (EWC), Volunteer State Community College, Gallatin, Tennessee (JS), and Jackson State Community College, Jackson, Tennessee (FD).** Data are presented for three secondary but relatively old Cumberland River bottomland forest stands. St. Stevens Woods, a 10 ha tract within Land Between The Lakes, Lyon County, Kentucky, was designated a Tennessee Valley Authority Ecology Study Area in 1973. Thirty species were sampled, indicating canopy (dbh  $\geq 10.2$  cm) dominance by *Liquidambar styraciflua*, *Quercus pagoda*, *Nyssa sylvatica*, and *Acer rubrum*. Cross Creeks Woods is a 15 ha stand within the Cross Creeks National Wildlife Refuge, Stewart County, Tennessee. Of the 25 canopy species sampled, dominance was by *Liquidambar styraciflua*, *Fagus grandifolia*, *Ulmus rubra*, and *Carya ovata*. Long Pond Slough, a designated Tennessee wetland in Montgomery County, is partly owned and managed by the Tennessee Wildlife Resources Agency. The 12 ha site was selectively harvested after our sampling in 1972. The sample of 428 trees with dbh  $\geq 10.2$  cm yielded 30 taxa dominated by *Ulmus rubra*, *Celtis laevigata*, *Carya cordiformis*, *Quercus shumardii*, *Celtis occidentalis* and *Carya laciniosa*. The three stands are further characterized and compared with the scant information available on pre-settlement forests. Sites of data archival are noted.

TWENTY YEARS OF FOREST CHANGE AT RADNOR

LAKE NATURAL AREA, DAVIDSON COUNTY, MIDDLE TENNESSEE. **Joe Schebig**, Department of Biology, Volunteer State Community College, Gallatin, Tennessee, and Center for Field Biology, Austin Peay State University, Clarksville, Tennessee. A 1994 analysis of five mature forest communities at Radnor Lake Natural Area near Nashville, Tennessee, was compared with a similar 1974 study to ascertain successional trends in this protected area. The importance value ( $IV = (\% \text{ density} + \% \text{ basal area} + \% \text{ frequency})/3$ ), of *Acer saccharum* increased in all communities, and its overall IV (average of IVs for all communities) increased from 10.0 in 1974 to 15.3 in 1994. The overall IV of *Celtis occidentalis* rose from 3.4 to 7.6 and showed increases in four of the five communities. The IV of *Acer saccharinum* in the lakeshore community increased from 10.8 to 30.3, while the IV of *Acer saccharum* ssp. *nigrum* increased from 2.8 to 11.8 in the mesic-slope community and from 3.3 to 4.9 in the ravine community. Taxa that declined in IV included *Carya cordiformis* (10.5 to 2.7, mesic-slope community), *Juglans nigra* (4.0 to 2.6, mesic-slope community; 8.3 to 5.1, ravine community), *Populus deltoides* (12.1 to 3.1, lakeshore community), *Quercus marilandica* (1.2 to 0.0, ridge community), *Quercus rubra* (8.9 to 0.0, dry-slope community; 12.0 to 10.3, mesic-slope community; 4.0 to 1.6, ravine community), *Salix nigra* (14.0 to 0.9, lakeshore community), and *Ulmus* spp. (6.5 to 2.5, mesic-slope community; 25.1 to 0.9, ravine community; 24.7 to 15.7, lakeshore community). The other 36 sampled taxa of trees exhibited relatively minor changes in IV over the 20-year period. Total densities of stems decreased in all communities. In 1994, the dominant taxa of trees ranked by IV were *Quercus montana*, *Fraxinus quadrangulata*, and *Carya ovata* on the ridges; *Acer saccharum*, *Celtis occidentalis*, and *Quercus montana* on the dry slopes; *Acer saccharum*, *Fraxinus americana*, and *Quercus rubra* on the mesic slopes; *Acer saccharum*, *Carya cordiformis*, and *Celtis occidentalis* in the ravines; and *Acer saccharinum*, *Celtis laevigata*, and *Ulmus americana* on the lakeshore.

ESTABLISHING AN URBAN ARBORETUM. **Mary C. Marshall**, **Kent Gallaher** and **Julie Berbiglia**, Lipscomb University, Nashville, Tennessee (MCM, KG), and Scarritt-Bennett Center, Nashville, Tennessee (JB). An arboretum was established at the Scarritt-Bennett Center, a ten acre international educational and conference center, in Nashville, Davidson County, Tennessee. This study focused on the identification, cataloging, and mapping of the diversity of tree species occurring at the center, and the creation of a self-guided tree tour, both of which were critical in the arboretum application process. The study identified some 25 species of trees on the ten acre campus including many common species (*Acer rubrum*, *Acer saccharum*, *Celtis occidentalis*, *Fraxinus pennsylvanica*, *Ulmus americana*) and several exotic and somewhat rare species (*Magnolia acuminata*, *Magnolia soulangiana*, *Paulownia tomentosa*, *Pinus lambertiana*). The brochure developed for the self-guided tree tour provides historical information, everyday uses, and interesting facts about each tree on the tour.

PRELIMINARY STUDIES OF PRIMARY PRODUCTION IN THE SULPHUR FORK CREEK WATERSHED, ROBERTSON COUNTY, TENNESSEE. **Jefferson G. Lebkuecher**, **Lillian F. Barber\***, **Kellie L. Wallace\*** and **Andrea M. Brown\***, Austin Peay State University, Clarksville, Tennessee. In support of a program to improve water quality in the Sulphur Fork Creek watershed of Robertson County, Tennessee, measurements of

photoautotrophic periphyton production and physiological status were determined in two springs and in an upper reach and a lower reach of Miller Creek. Periphytometers holding glass slides 5 cm below the surface were used to sample periphyton during the last two weeks of August, 1997. Primary production was greatest in the lower reach of Miller Creek, followed by the upper reach of Miller Creek, Blue Spring, and Wessington Spring as determined by significant differences in periphyton dry weight and chlorophyll-a concentration. The physiological status of photoautotrophic periphyton, as determined by photosystem-II photochemical efficiency, from Blue Spring was significantly lower relative to periphyton sampled from Wessington Spring. Photosystem-II photochemical efficiency of periphyton sampled from lower Miller Creek was significantly lower Miller Creek was significantly lower relative to periphyton sampled from upper Miller Creek. The results indicate poor water quality in Blue Spring relative to Wessington Spring and in lower Miller Creek relative to upper Miller Creek.

DEVELOPMENT OF PHOTOSYSTEM-II CENTERS UPON LIGHT EXPOSURE OF DARK-GROWN SUNFLOWER SEEDLINGS. **Jefferson G. Lebkuecher**, **Andrea M. Brown\***, **Melanie L. Dennis\***, **Kurt A. Haldeman\***, **Christine E. Harris\***, **Sonia L. Holz\***, **Sary A. Joudah\***, **Jamie E. Mells\*** and **Darcy A. Minton\***, Austin Peay State University, Clarksville, Tennessee. Chlorophyll a fluorescence was used to follow light-induced assembly of photosystem (PS)-II complexes upon light exposure of sunflower seedlings germinated in the dark for six days. The results indicate that development involves the assembly of PS-II complexes which are deficient in both water oxidation and electron-transfer capacity between quinone<sub>A</sub> and quinone<sub>B</sub>. With increasing time of illumination, newly synthesized PS-II complexes exhibit increased capacities to extract electrons from water and to pass electrons through quinone<sub>B</sub> to the cytochrome b<sub>6</sub>-f complex of the photosynthetic electron transport chain. These results support the hypothesis that during PS II development, PS II quinone<sub>B</sub>-nonreducing centers are assembled followed by the conversion of these centers into PS II quinone<sub>B</sub>-reducing centers.

DESICCATION-TIME LIMITS OF PHOTOSYSTEM-II RECOVERY IN *EQUISETUM* SPORES: IMPLICATIONS ON SPHENOPHYTA DISTRIBUTION AND EXTINCTION. **Jefferson G. Lebkuecher**, Austin Peay State University, Clarksville, Tennessee. *Equisetum* is the only surviving genus of the Sphenophyta, which during the Carboniferous, included many herbaceous and arborescent genera. The chloroplast-containing spores of *Equisetum* survive drying, but cannot tolerate this state for more than two weeks. Previous research from this lab has demonstrated that *Equisetum hyemale* spores cannot recover photosystem-II activity upon rehydration after two weeks in the desiccated state. In the present study, the reasons for the loss of photosystem-II activity were examined. Experimental spores were dried for varying times and following wetting, their ability to recover aspects of photochemistry were evaluated using chlorophyll a fluorescence. The results indicate that the inability to recover both water oxidation and electron transfer between quinone<sub>A</sub> and quinone<sub>B</sub> after two weeks in the dry state are responsible for the short viability of *Equisetum* spores. The Carboniferous provided ideal conditions for sphenophytes, virtually all of which produced thin-walled, *Equisetum*-like spores. Thomas and Spicer (1987) suggested that one factor leading to the mass extinction of sphenophytes during the arid Triassic may

have been the inability for rhizome growth in dry soil. This study poses the interesting possibility that inhibition of the recovery of spore photosystem-II competence following two weeks in the dry state also may have contributed to sphenophyte extinction and the restriction of extant species to wet habitats.

**THE EFFECT OF NaCl ON GROWTH AND NITROGEN FIXATION IN *LEUCAENA LEUCOCEPHALA* VAR. K-8.** *Annie Anthraper\* and John D. DuBois, Middle Tennessee State University, Murfreesboro, Tennessee.* *Leucaena leucocephala* var. K-8 is a fast-growing tropical leguminous tree that has multiple economic uses. This study was conducted to evaluate the effect(s) of varying NaCl concentrations on growth, dinitrogen fixation activity and total tissue-N in *Leucaena leucocephala*. Plants were grown from seed in vermiculite and given a N-free fertilizer every two weeks. At 13 weeks, plants were treated with deionized water (control), 0.00625 M, 0.0125 M, 0.025 M, 0.05 M, or 0.1 M NaCl in addition to the biweekly fertilizer. Growth was measured as plant height, number of leaves, and dry tissue mass. Dinitrogen fixation was measured by the acetylene reduction assay. Tissue-N was determined using Kjeldahl analysis. Salt treatments of 0.025 M and higher showed the greatest impact on growth, dinitrogen fixation and tissue-N. By week four of the treatments, plants receiving the higher salt concentrations died or substantially curtailed activity. Plants receiving the lower salt treatments (0.00625 M and 0.0125 M) responded similarly to the control plants. We conclude that NaCl concentrations greater than 0.025 M have a significant effect on the growth, dinitrogen fixation activity and tissue-N levels in *Leucaena leucocephala*, at least while the plants are still young (< one year old).

**THE IMPACT OF FERAL HORSES ON SPATIAL CHANGES IN PLANT COMMUNITY COMPOSITION AND STRUCTURE IN A COASTAL DUNE SYSTEM.** *David Royal\* and Jonathan Evans, The University of the South, Sewanee, Tennessee.* The ecological implications of feral horses on coastal dune systems has been largely overlooked across the Southeastern United States, despite serious land management considerations. Shackleford Banks is a barrier island off the coast of North Carolina that is presently inhabited by approximately 110 feral horses. Six horse enclosures were established in dunes and swales between 1992 and 1995 to monitor the effect of horse activity on plant community composition and structure. Species percent cover was measured in each enclosure and equivalent control and then converted to values of relative abundance and grouped by growth-form guild. Evidence is presented suggesting that horse activities inhibit the establishment of bunch grasses in dune communities and the establishment of shrubs in swale communities. Both of these plant guilds play an important intermediate role in the perpetual establishment of maritime forest along dune/swale gradients. Management implications of horse population control for maritime forest expansion on barrier islands is discussed.

**SEWANEE HERBARIUM.** *Mary Priestly, The University of the South, Sewanee, Tennessee.* Following a recent loss of herbaria, there has been a worldwide revitalization of herbarium collections that has resulted from an increased focus on plant biodiversity conservation and growing concern about global change issues. While herbaria were once viewed simply as repositories of pressed plant specimens utilized only by systematists, they now serve in a greater capacity as clearinghouses for the assimilation and dissemination of plant biodiversity information in a

given region. Through the use of advanced computer database systems and the internet, it has become possible to make these collections of dried plant specimens come alive for a wide variety of new users. The Sewanee Herbarium has expanded its traditional role of teaching and research and has moved strongly in the direction of conservation and outreach. It was among the first herbaria in the Southeastern United States to develop a website, to computerize its collection information, and to allow its collection databases to be searchable over the World Wide Web. It is a repository for all plant collections made in its immediate four-county area (Franklin, Grundy, Marion, and Coffee) by botanists with the Tennessee Division of Natural Heritage, the Nature Conservancy, and the Arnold Engineering and Development Center (AEDC-United States Dept. of Defense). Current research projects include a Flora of the Sewanee Domain and a Flora of AEDC.

## CELL AND MOLECULAR BIOLOGY SECTION

John Palisano, Chair

**REOVIRUS SEROTYPE-DEPENDENT REPLICATION IN ALVEOLAR MACROPHAGES.** *Sean M. O'Donnell\* and Anthony L. Farone, Middle Tennessee State University, Murfreesboro, Tennessee.* The interaction of viruses with pulmonary tissues is a longstanding concern of biomedical research. The goal of this work was to begin to understand the mechanisms by which reovirus type 1 Lang (T1L) and type 3 Dearing (T3D) mediate differential regulation of the inflammatory cytokines in alveolar macrophages. Previous studies have shown T3D induces enhanced cytokine production compared to T1L in the rat alveolar macrophage cell line, NR8383. The purpose of this study was to determine whether reovirus T1L or T3D replicates in an alveolar macrophage cell-line and if there is a serotype difference in the efficiency of replication. While both serotypes replicated in the macrophages, we found that T3D replicated to significantly lower titers than T1L. Our findings suggest that the increased cytokine expression stimulated by T3D is not the result of increased viral replication. These studies support the hypothesis that differences in macrophage gene expression are due to serotype-specific differences in the viral proteins.

**REGULATION OF <sup>3</sup>H-OXYTOCIN BINDING SITES IN PORCINE MYOMETRIAL CELL MONOLAYER CULTURES.** *Kurt Haldeman\* and Sarah Lundin-Schiller, Austin Peay State University, Clarksville, Tennessee.* Myometrium is the smooth muscle layer of the uterus that contracts during labor to expel the fetus. Oxytocin (OT) is a potent myometrial contractile agent. However, the effect of OT is dependent on the number of OT receptors expressed on the surface of the myometrial cells. Myometrial OT receptor (OTR) density is up-regulated at term in pigs and in several other species studied to date. The precise endocrine milieu eliciting this increase is uncertain. We have grown myometrial monolayer cultures in RPMI-1640 plus charcoal stripped fetal calf serum and insulin ± estradiol (10<sup>-7</sup> M) and determined them to be valid models for study of OTR expression. Myometrial cells grew in parallel arrays at confluence. OTR expression was determined by measuring specific <sup>3</sup>H-OT binding. Cells grown in control medium (no estradiol) expressed OTR at levels ranging from 1.63 to 72.2 fmol/mg protein. Estradiol treat-

ment did not consistently up-regulate OTR expression in these cultures.

**EXPRESSION OF <sup>3</sup>H-OXYTOCIN BINDING SITES IN PORCINE LUMINAL ENDOMETRIAL CELLS IN VITRO: REGULATION BY STEROID HORMONES.** *Jamie Mells\* and Sarah Lundin-Schiller, Austin Peay State University, Clarksville, Tennessee.* Endometrial tissue has been shown to express oxytocin receptors (OTRs) in vivo and to produce prostaglandin F<sub>2α</sub> in response to oxytocin in vitro. An increase in circulating estradiol concentrations has been considered a possible signal stimulating expression of OTRs. The goal of this study was to determine effects of estradiol (E2) and progesterone (P4) on endometrial OTR expression in vitro. Tissues were collected from gilts (n=4) in the follicular phase of the estrous cycle and cultured in RPMI 1640 plus charcoal stripped fetal calf serum, insulin, antibiotics and antimycotics. Cultures were grown to confluence and then treated with either control medium, 10<sup>-8</sup> M E2, or 15 ng/ml P4 followed by 10<sup>-8</sup> M E2. OTR expression was determined in triplicate by measuring specific <sup>3</sup>H-OT binding. As compared to control OTR expression, steroid treatments reduced mean OTR expression by as much as 50%. This finding suggests that regulation of OTR expression is more complex than previously believed.

**THE EFFECT OF ACTIVATED PEROXISOME PROLIFERATOR-ACTIVATED RECEPTOR- $\gamma$  (PPAR- $\gamma$ ) ON SIGNAL TRANSDUCERS AND ACTIVATORS OF TRANSCRIPTION (STATS) DURING 3T3-L1 ADIPOCYTE DIFFERENTIATION.** *Sherry Young\* and William Stewart, Middle Tennessee State University, Murfreesboro, Tennessee.* Tumor necrosis factor- $\alpha$  was shown to inhibit 3T3-L1 adipocyte differentiation as well as the expression of Signal Transducers and Activators of Transcription (STAT)s 1 and 5 during the inhibition of differentiation, as previously reported. In addition, we examined the effect of activated peroxisome proliferator-activated receptor- $\gamma$  (PPAR- $\gamma$ ) on STAT expression during adipocyte differentiation. PPAR- $\gamma$  is an adipose specific transcription factor that is induced early during adipocyte differentiation and is involved in the regulation of differentiation. Thiazolidinediones (TZD) are potent ligands for PPAR- $\gamma$ . The TZD Englitazone and TNF- $\alpha$  were added to preadipocytes that had been induced to differentiate. Western blot analysis showed that the TZD restored the expression of STATs 1 and 5. Experiments using Oil Red-O to determine lipid accumulation supports the conclusion that TZD treatment also restored the adipocytes ability to differentiate. This suggests that STATs 1 and 5 in addition to PPAR- $\gamma$  are involved in the differentiation of adipocytes.

**MORPHOLOGICAL AND HISTOCHEMICAL CHARACTERIZATION OF PORCINE ENDOMETRIAL CELLS IN VITRO.** *Angela M. Hahn\* and Sarah Lundin-Schiller, Austin Peay State University, Clarksville, Tennessee.* Uterine endometrium incorporates layers of luminal epithelium and connective (stromal) tissue. The objective of this study was to characterize growth pattern and intermediate filament expression of porcine endometrial luminal and stromal cells in culture. Endometrium was dissected, differentially digested to separate luminal and stromal cells, and grown. Cultures were observed and photographed daily until confluent. Luminal cells, which appeared polyhedral, began with small islands and expanded to form a single layer covering the dish. Stromal cells appeared stellate and grew randomly, of-

ten layering over one another. Luminal and stromal cells were stained using double-indirect immunofluorescence and visualized with bisbenzamide. Vimentin is expressed in luminal and stromal cells, while cytokeratin is only expressed by luminal cells. The luminal cultures exhibit epithelial cell morphology and intermediate filament expression characteristic of epithelial cells of mesodermal origin. Stromal cells exhibit conventional fibroblast morphology and intermediate filament expression.

## CHEMISTRY SECTION

Martin Stewart, Chair

**CONFORMATIONAL EFFECTS ON THE KINETICS OF FLAVIN-MEDIATED REDOX REACTIONS.** *Justin J. Hasford\* and Carmelo J. Rizzo, Vanderbilt University, Nashville, Tennessee.* We have recently synthesized a series of benzosubstituted isoaloxazines and reported the conformational effects of C9-substitution on the reduction potentials for these flavins (J. Org. Chem. 62:5244-5245, 1997). We now report the effects of benzosubstitution on the kinetics of two flavin-mediated redox processes, the reduction of mercury (II)-EDTA and the oxidation of dithiothreitol. The kinetic data is compared to previously reported thermodynamic data, which indicate that both conformational and electronic control of flavin redox chemistry occur in a predictable manner based on substitution patterns. However, an off-linear kinetic effect is observed for 8,9,10-trimethylisoalloxazine.

**THE ASYMMETRICAL GROUND STATE OF CYCLOPENTADIENYLBORANES: PREDICTIONS OF AN AB INITIO MODEL.** *Brian Hill\* and William H. Ilesley, Bryan College, Dayton, Tennessee, and Middle Tennessee State University, Murfreesboro, Tennessee.* Energy optimized geometries of the ground and transition states of cyclopentadienylborane are presented for the degenerate 1,5-sigmatropic rearrangement of three substituted cyclopentadienylboranes. For each, the ground state predicted using the RHF/6-31G\* method is asymmetrical. Activation energies were predicted for pentamethylcyclopentadienyldifluoroborane and pentamethylcyclopentadienyldichloroborane using both MNDO and RHF/6-31G\* methods, and compared with previously reported experimental values. Previously reported x-ray crystallographic data for bis(pentamethylcyclopentadienyl)fluoroborane was also compared with MNDO and RHF/3-21G\* predictions. For each, predictions from RHF calculations were closer to experimental values than predictions from MNDO calculations.

**PARTITIONING INTERWELL TRACER TEST FOR DENSE NONAQUEOUS PHASE LIQUID IN AQUIFERS: A MATHEMATICAL MODEL.** *David J. Wilson, Ronald A. Burt and Robert D. Norris, Eckenfelder Incorporated, Nashville, Tennessee.* The assessment of the presence of dense nonaqueous phase liquid (DNAPL) like trichloroethylene in contaminated aquifers has been a pressing problem in remediation. Existing techniques give only extremely localized measurements (drilling and sampling) or are so inaccurate as to be useless (geophysical methods). Recently groups at the University of Texas and the University of Florida proposed a technique for characterizing DNAPL sites which gives a global measure of the quantity of DNAPL within the test region. This Partitioning Interwell Tracer Test (PITT)

involves injection of nonpartitioning and partitioning tracers through a set of injection wells and subsequent recovery of these tracers through a set of recovery wells for analysis and interpretation. A two-dimensional mathematical model for this process will be described. Results showing the effects of DNAPL mass and distribution, tracer partition coefficient, pumping rate, and other parameters on the outcome of a PITT will be presented.

**SLOW ELECTRON DYNAMICS IN ALKALI METAL CLUSTERS.** *Preston J. MacDougall and M. Creon Levit, Middle Tennessee State University, Murfreesboro, Tennessee, and NASA Ames Research Center, Moffett Field, California.* The electron density is an observable property of matter. It can also be calculated very accurately with state-of-the-art quantum chemistry software. In position space, topological analyses of the electron density, and its Laplacian, have revealed features that are identified as the physical manifestation of such chemical concepts as atoms, bonds, and electron pairs. The electron density in momentum space can also be calculated or measured. Results of analyses of the electron density, and its Laplacian, in momentum space are presented for clusters of alkali metal atoms. These analytical tools provide model independent information that provide new insight into the electron dynamics of matter.

**CLEANUP OF CONTAMINATED AQUIFERS WITH OXYGEN-RELEASING SOLIDS.** *David J. Wilson and Robert D. Norris, Eckenfelder Incorporated, Nashville, Tennessee.* The use of oxygen release compound (ORC) in passive wells is of interest in the bioremediation of groundwater polluted with biodegradable contaminants. Labor and operating costs may be substantially lower than those of more conventional bioremediation techniques. However, improperly designed ORC systems may result in a pin-stripe pattern of contamination downgradient from the ORC wells. A mathematical model for bioremediation with ORC systems has been developed which can be run on microcomputers. Use of the model permits design of minimum cost systems with extent of pin-stripping controlled within preset limits. The dependence of model results on such system variables as well spacing and influent contaminant concentration will be discussed.

**AN INVESTIGATION OF THE THERMAL PROPERTIES OF VINYLIDENE CHLORIDE-METHYL ACRYLATE COPOLYMERS.** *Edward R. Covington, Edreese AlSharaeh\* and Deborah Dunson\*, Tennessee State University, Nashville, Tennessee (ERC, EA), and Virginia Polytechnic Institute and State University, Blacksburg, Virginia (DD).* Copolymers of vinylidene chloride and methyl acrylate containing 90-94 percent vinylidene chloride were prepared by emulsion polymerization, isolated and the vinylidene chloride content of the polymers was confirmed by chlorine analyses. Thermal properties were observed by differential scanning calorimetry (DSC) and thermomechanical analysis. Three transitions observed in the DSC thermograms consist of a glass transition and two endothermic peaks. This is consistent with data reported for vinylidene chloride copolymers by earlier workers. The endotherm at the higher temperature corresponds to the melting points of the polymers. Thermomechanical analysis of amorphous polymers utilizing an expansion probe showed transition near the glass temperatures that resulted from penetration by the probe rather than expansion. Large changes in dimension occurred in the temperature range of the lower temperature endotherm indicating flow. The transitions in these poly-

mers are used to interpret earlier observations of properties of films coated with vinylidene chloride copolymers.

**THE INDIVIDUAL NATURE OF GAS CHROMATOGRAPHIC PROFILES OF HUMAN SKIN SURFACE LIPIDS.** *Kelly Dean Hopkins\* and Linda Arney Wilson, Middle Tennessee State University, Murfreesboro, Tennessee.* In a situation in which a victim is attacked, cosmetics from her face may be transferred to the clothing of the assailant. Currently, only a comparison of the cosmetics is made. The present study was designed to determine whether human skin surface lipid gas chromatographic profiles are individual in nature and can be used to link an assailant to a victim. Samples were collected over four months from 26 individuals. Wax esters and cholesterol esters were separated from the other skin oil components by solid phase extraction and analyzed by Gas Chromatography (GC). They were then converted to their fatty acid methyl esters which were also analyzed by GC. Using peak height data, statistical comparisons of each chromatogram to all others were made. The Pearson correlation coefficient provided the best method of comparison. By making visual comparisons of the chromatograms, samples belonging to other individuals could be eliminated. While these results do not demonstrate that skin oils are totally individual in nature, they do show that comparison of skin oil chromatograms can provide valuable forensic evidence.

**AN INTRODUCTION TO 125-TELLURIUM NMR CHEMICAL SHIFT REFERENCES.** *Allen Bailey\* and Judith Iriarte-Gross, Middle Tennessee State University, Murfreesboro, Tennessee.* The increasing interest of the chemical community in tellurium chemistry dictates the need for a thoroughly characterized 125-tellurium chemical shift reference standard. To date, there has been no universal agreement on a reference standard. Neat dimethyltelluride ( $\text{Te}(\text{CH}_3)_2$ ) seems to be the reference of choice for reported 125-Tellurium NMR chemical shifts. However, since tellurium chemical shifts are solvent, temperature, concentration, and pH dependent, detailed studies of potential 125-tellurium NMR chemical shift references are necessary. Four possible 125-tellurium NMR chemical shift references, dimethyltelluride ( $\text{Te}(\text{CH}_3)_2$ ), telluric acid ( $\text{Te}(\text{OH})_6$ ), bis(diethylthiocarbamate) tellurium II ( $\text{Te}(\text{S}_2\text{CNET}_2)_2$ ) and trimethyltellurium iodide ( $(\text{CH}_3)_3\text{TeI}$ ) have been evaluated and will be discussed.

**MOLAR ABSORPTIVITY OF SOME ORGANIC RADICALS.** *Chris Smalley\* and Rudy Gostowski, Austin Peay State University, Clarksville, Tennessee.* The UV-visible spectrum of cations, radicals, and anions derived from triphenyl methane, 9-o-tolylfluorene and 9-mesitylfluorene were taken. The molar absorptivity of these species was compared. The cations and anions exhibited similar values while the radicals were three orders of magnitude lower. This implies a forbidden process with the unpaired electron.

**THE USE OF MASS SPECTRAL ANALYSES TO DETERMINE EMPIRICAL FORMULAS.** *Eugene A. Kline and Donald Gregory Wheatley, Tennessee Technological University, Cookeville, Tennessee.* The use of mass spectral analysis to determine empirical formulas is commonly accomplished with high resolution mass spectroscopy. The concept for determining molecular formula as well as composition of fragments is easily and quickly understood by first year organic chemistry students. The low res-

olution mass spectra have characteristic patterns of peak heights which can be very useful in identifying the kinds and numbers of atoms. The quantitative basis for these peak heights, a key for fully appreciating mass spectroscopy, is more difficult to quickly understand. Computer programs with graphical representations use atoms common in organic molecules (C, H, N, O, S, Si, Cl, and Br) to quickly learn about many patterns of relative peak height ratios and their importance in giving clues to a compound's elemental composition and its empirical formula. The programs are useful in comparing the relative peak heights of a large number of combinations of atoms having very complicated peak height ratios with real mass spectral results to estimate elemental composition.

**HENRI ERNI (1822-1885): TENNESSEE'S FIRST CONSULTING CHEMIST.** *James X. Corgan, Austin Peay State University, Clarksville, Tennessee.* Born in Switzerland, Erni came to the United States in 1849, joining Yale's Sheffield Scientific School. He taught botany and assisted in chemistry. He was well recommended but lacked a degree. In 1850 he moved to East Tennessee University, in Knoxville, teaching chemistry and other subjects. He began to publish prolifically. While marriage anchored him in Tennessee, from 1852 through early 1857 he accepted a traveling lectureship and other positions in New England. He received an A.M. and M.D., both honorary, from the University of Vermont before returning to East Tennessee University. In 1859 he moved to Shelby Medical College in Nashville. His contract permitted use of college resources for a personal consulting business. Urine analysis was probably his most used service. At the time there were two other consulting scientists in Tennessee, two geologists.

**SEASONAL VARIATIONS IN THE MINIMUM PRESSURE OBTAINED FROM A WATER ASPIRATOR.** *Martin V. Stewart, Natalie A. Tate\*, David G. Lancaster\* and James C. Howard, Middle Tennessee State University, Murfreesboro, Tennessee.* The vacuum from traditional water aspirators has become undependable in the Davis Science Building due to low and variable water pressures caused by both unprecedented campus expansion and the installation of reduced-pressure-principle back-flow preventers. The ultimate vacuum achievable with a water aspirator is limited to the vapor pressure of water, and this was obtained from the marginal water supply using a type of plastic aspirator designed to consume less water. Sixty pressure measurements made from August to November exhibited a continuous decrease as the tap water temperature decreased. Application of the Clausius-Clapeyron equation was suggested by Dr. Roy W. Clark, which afforded the literature value of 40.7 kJ/mol for the vapor pressure of water.

**MOLECULAR MODELING AND COMPUTATIONAL STUDIES OF PLATINUM (II) AND (IV) ANTI-CANCER DRUGS.** *Thomas R. Klinckman\* and Lori L. Slavin, Austin Peay State University, Clarksville, Tennessee.* Computer-aided drug design is an example of the potential for modern computational chemistry to aid the traditional experimental search for new platinum (II) and (IV) anticancer compounds. Synergistic theory-experimental studies provide a powerful approach to finding second and third generation platinum drugs with a greater range of therapeutic activity and reduced toxicity. Quick and efficient modeling is obtained despite simplifications used in constructing the force field. The new force field allows accurate structural predic-

tion for bond lengths and bond angles as compared to X-ray crystallography data.

**OBSERVING THE RELATIONSHIP BETWEEN COUPLING RATE CONSTANTS AND STERIC HINDRANCE OF CARBON-CENTERED RADICALS.** *Sabrina Bonner\* and Rudy Gostowski, Austin Peay State University, Clarksville, Tennessee.* The bimolecular coupling rate constants of some aryl-substituted fluorenyl and xanthenyl radicals were determined utilizing fast scan cyclic voltammetry and digital simulations. The rate constant was attenuated from the diffusion-limited value as the twist of the aryl substituent increased; the twist was described by an appropriate dihedral angle. However, this quantity was insufficient to represent the steric bulk of substituents on the aryl ring. A thickness parameter obtained from a MOPAC RHF-PM3 calculation correlated well with the coupling rate constants of the fluorenyl and xanthenyl radicals considered.

**PROPERTIES OF SEVEN-COORDINATE PENTAGONAL BIPYRAMIDAL Mn (II) AND Ni (II) COMPLEXES.** *Jimmy H. Davis and Timothy S. Rogers\*, Union University, Jackson, Tennessee.* Seven-coordination of first-row transition metals was rarely observed until the 1970's, and is still uncommon today. It was also doubted that such coordination could occur in most first-row transition metals because of the effects of crystal field energy. However, since this time, ligands have been developed that enable seven-coordinate complexes to be formed with all first-row transition metals. Two of these ligands that will be presented are 2,6-diacetylpyridine bis-semicarbazone (DAPSC) and 2,6-diacetylpyridine bis-benzoic acid hydrazone (DAPBH). These two ligands were completed with the first-row transition metals Mn (II) and Ni (II) along with various anions. This presentation will exhibit the properties of seven-coordinate pentagonal bipyramidal complexes using IR, UV, Conductivity, NMR, and Cyclic Voltammetry techniques.

**INVESTIGATION OF TRIMETHYLTELLURONIUM IODIDE AS A 125-TELLURIUM NMR CHEMICAL SHIFT REFERENCE.** *Allen Bailey\*, Brian Hill\*, Meredith Rogers\*, William H. Ilsley and Judith Iriarte-Gross, Middle Tennessee State University, Murfreesboro, Tennessee (AB, MR, WHI, JIG) and Bryan College, Dayton, Tennessee (BH).* Interest in tellurium (Te) chemistry has grown rapidly in recent years. The utility of tellurium nuclear magnetic resonance spectroscopy has been demonstrated. The  $^{125}\text{Te}$  nucleus is extremely sensitive to its electronic environment, and the large  $^{125}\text{Te}$  chemical shift range reflects this sensitivity. Because the  $^{125}\text{Te}$  nucleus is highly sensitive to a variety of parameters, detailed studies of tellurium compounds proposed as references for  $^{125}\text{Te}$  NMR spectroscopy must be conducted. Trimethyltelluronium iodide is of interest as a reference for  $^{125}\text{Te}$  NMR spectroscopy because of its solubility in water which is of importance for biochemical studies. Chemical shift data and ab initio calculations are reported.

**INITIAL STUDIES ON THE SYNTHESIS AND CHARACTERIZATION OF ZINC OXIDE SOL-GEL MATERIALS.** *Melanie M. McDaniel\*, Freneka Minter\* and Judith Iriarte-Gross, Middle Tennessee State University, Murfreesboro, Tennessee (MMM, JIG), and Riverdale High School, Murfreesboro, Tennessee (FM).* The sol-gel process using zinc salts provides a new method of investigation for the controlled synthesis of zinc oxide and zinc sulfide. Classical sol-gel reactions were utilized

and optimized to synthesize zinc doped sol-gel materials. Factors such as pH, alkoxide, molar ratio of water to alkoxide, and temperature affect the nature of the sol-gel products. In this work, the pH of the reactions was varied. Different products were obtained. Materials are being characterized by NMR and IR.

**A TIME-RESOLVED STUDY OF THE CHEMILUMINESCENCE OF LIGHTSTICKS.** *Eric Boswell\* and Gary D. White, Middle Tennessee State University, Murfreesboro, Tennessee.* Lightsticks are used in a wide variety of applications including children's toys and scuba diving. They emit light through chemiluminescence. Their colors and durations vary. We have studied the decay of chemiluminescence using the E0-85 Spectrophotometer. The temperature of the reaction was controlled by immersing the lightstick in a constant temperature bath. Emission spectra were collected as a function of time at different temperatures. Our results show that the chemiluminescence decays rapidly at first and then more slowly. This is consistent with observations by other investigators. These results are useful in illustrating how the kinetics of lightsticks are affected by temperature. These experiments also proved to be an excellent means of illustrating the basic principles of chemical kinetics.

**TEACHING INTRODUCTORY BIOCHEMISTRY WITHOUT GOING BROKE.** *Barbara J. Walton\*, Ellen F. Verdel and Paul C. Kline, Cumberland University, Lebanon, Tennessee (BJW) and Middle Tennessee State University, Murfreesboro, Tennessee (EFV, PCK).* In 1977, Jeffrey A. Hurlbut stated that "introductory biochemistry laboratory is a difficult course to teach because of several factors. The students have varied backgrounds; the equipment and chemicals are expensive; the instruments are in constant demand; the class sizes are large; and there are few biochemistry laboratory manuals." Twenty years later the same factors remain detrimental to introductory biochemistry. The existing laboratory manuals are geared mainly for full year biochemistry courses, rather than an introductory level course. This manual written for an Introductory Biochemistry course offers 13 experiments, which provide a variety of modern techniques, using relatively inexpensive equipment and chemicals. The experiments include techniques in gel filtration, thin-layer chromatography, electrophoresis, DNA isolation, DNA fingerprinting, and molecular modeling.

**X-RAY CRYSTAL STRUCTURES OF  $(C_5Cl_5)_2Hg$  AND 2,4,6-TRIMETHOXYPHENYL  $(C_5Cl_5)_2Hg$ .** *Haiping Lu\*, William H. Ilsley, Paul Dickson and John P. Oliver, Middle Tennessee State University, Murfreesboro, Tennessee (HL, WHI) and Wayne State University, Detroit, Michigan (PD, JPO).* The X-ray crystal structures of bis(pentachlorocyclopentadienyl)mercury,  $(C_5Cl_5)_2Hg$  and 2,4,6-trimethoxyphenyl(pentachlorocyclopentadienyl)mercury,  $2,4,6-Me_3C_6H_2(C_5Cl_5)_2Hg$  have been determined.  $(C_5Cl_5)_2Hg$  crystallizes in two crystalline forms. Form I consists of rectangular crystals belonging to the space group P1-bar having unit cell parameters of  $a = 8.49$  A,  $b = 9.518$  A,  $c = 12.262$  A,  $\alpha = 73.13^\circ$ ,  $\beta = 87.78^\circ$ , and  $\gamma = 70.78^\circ$ . Form II consists of octahedral crystals belonging to the space group  $P4_12_12$  with unit cell parameters of  $a = b = 11.300$  A,  $c = 13.477$  A and  $\alpha = \beta = \gamma = 90.00^\circ$ . In each molecule the mercury atom exhibits linear geometry and the  $C_5Cl_5$  rings adopt a staggered arrangement when viewed along the C-Hg bond.  $2,4,6-Me_3C_6H_2(C_5Cl_5)_2Hg$  crystallized in the monoclinic space group C2/c with unit cell parameters of  $a = 10.721$  A,  $b = 16.08$  A,  $c = 21.275$  A, and

$\beta = 91.28^\circ$ . The mercury exhibits linear geometry and the  $C_5Cl_5$  group adopts a half chair conformation. All three structures exhibit secondary Hg-Cl close contacts.

**THE BIOSYNTHESIS OF SELENIUM AND TELLURIUM CONTAINING RECOMBINANT HISTONES FOR CRYSTALLIZATION STUDIES.** *Alicia Hyatt\*, Mark Orr\* and Jeffrey Boles, Tennessee Technological University, Cookeville, Tennessee.* Knowledge of the three dimensional structure of macromolecules is of utmost importance in biology, medicine, and chemistry. While these data are difficult to obtain, to say the least, they are however necessary for the molecular based design of drugs. One of the most recent advances in determining 3D structure is through the biosynthetic incorporation of unnatural amino acids into the macromolecules of interest, namely proteins. These amino acids contain selenium (selenomethionine, SeMet) or tellurium (telluromethionine, TeMet) atoms which replace sulfur (an inferior, lighter atom for 3D structure determination of little interest to structural biochemists) in the protein. This technique has been shown to solve the well known phase problem of macromolecular crystallography. We propose to utilize this technique in our quest to determine the 3D structure of a biological complex containing histone proteins. Of the four histones present in the nucleosome core particle (H2A, H2B, H3 and H4) the preparation of two are described here, H2B and H3. The final and most critical step in these studies is a crystallization screening protocol whereby the proteins are subjected to a variety of conditions in order to "screen" them for the best conditions which result in crystal formation. The recombinant SeMet or TeMet containing histones will be co-crystallized with DNA at Gerard Bunicks laboratory at Oak Ridge National Laboratories.

**STRUCTURAL STUDIES OF PYROLIDONE CARBOXYL PEPTIDASE (PYRASE) FROM *STAPHYLOCOCCUS AUREUS*.** *Paramita Mookherjee\*, Alicia Hyatt\* and Jeffrey Boles, Tennessee Technological University, Cookeville, Tennessee.* The subject of this research was the expression, purification and characterization of wild type aminopeptidase by size-exclusion chromatography and determination of the experimental extinction coefficient. Pyrolidone carboxyl peptidase (PYRase), the aminopeptidase under investigation, is a proposed member of a new structural class of proteins, as none of the cloned homologous PYRases exhibit sequence homology with other known peptidases. The exact physiological function of PYRase remains unknown. *Staphylococcus aureus* PYRase was shown to exist as a dimer under native conditions and exhibited a molecular weight of 23kDa, as determined by size-exclusion chromatography in 6M guanidine HCl. The extinction coefficient was  $35,000 M^{-1} cm^{-1}$ .

**THE DETECTION OF SELENIUM AND TELLURIUM IN SELENO- AND TELLUROPROTEINS UTILIZING CAPILLARY ELECTROPHORESIS.** *Pavan Marpaka\* and Jeffrey Boles, Tennessee Technological University, Cookeville, Tennessee.* The detection of selenium and tellurium in proteins has become of interest lately owing to their utilization as x-ray diffraction labels and NMR probes. Current detection techniques include ICP and AAS, both of which are destructive yielding quantitative information alone. It would be desirable to have a simpler in house method of both quantitation and localization of selenium and tellurium content. In this study, we are attempting to exploit both spectroscopic differences (IR) and chemical reactivity differences

(with CNBr) between L-methionine, L-selenomethionine (SeMet) and L-telluromethionine (TeMet). We began by looking at the free amino acids in developing both techniques and are currently extending these experimental designs to the wild type, SeMet and TeMet-containing control proteins. The protein chosen for our study is *Escherichia coli* dihydrofolate reductase and is available in a methionine auxotrophe as *E. coli* DL41 (pCOCK). We have cultured *E. coli* DL41 (pCOCK) on defined media, produced and purified all three dihydrofolate reductases and will present our preliminary results concerning the detection and localization of SeMet and TeMet.

THE ATTEMPTED PREPARATION OF SELENIUM AND TELLURIUM CONTAINING ANALOGS OF TRYPTOPHAN USING TRYPTOPHAN SYNTHASE. **David O'kin\* and Jeffrey Boles**, *Tennessee Technological University, Cookeville, Tennessee*. There are currently only two metalloid-containing unnatural amino acids available for use as biosynthetically incorporated x-ray diffraction labels in proteins, selenomethionine (SeMet) and telluromethionine (TeMet). The latter of the two and is the most desirable from the standpoint of x-ray crystallography (TeMet), but is very difficult to work with due to its instability. X-ray crystallography requires a heavy-atom derivative be made of a protein in order to interpret the data from the diffraction experiment. In order to facilitate structural determinations in this manner it would be of interest to have available several such diffraction labels. This project concerns the synthesis of selenium and tellurium containing analogs of tryptophan. Chemical synthesis of this compound has proven unsuccessful due to the instability of several intermediates. Tryptophan synthase (TS) has been used for the preparation of many analogs of tryptophan using indole analogs as starting material. We obtained the expression system for the wild type heterotetrameric enzyme and the b2 subunit, and purified both by established protocols. We have performed control experiments synthesizing tryptophan from indole and designed a protocol ending with tests to see if the analog supports growth of a tryptophan of various tryptophan analogs will be presented.

SIMULATION OF THE ELECTRON TRANSFER RATES BETWEEN CYTOCHROME C PEROXIDASE AND FERROCENE. **Charles Andrew Boswell\* and Scott H. Northrup**, *Tennessee Technological University, Cookeville, Tennessee*. Ferrocenes have been studied by Sadeghi and Cass as electron shuttles to mediate and facilitate the electron transfer between an electrode and a metalloprotein in electrochemical experiments. In our study the bimolecular electron transfer reaction kinetics between cytochrome c peroxidase and several ferrocene derivatives of various charge have been simulated by the Brownian dynamics (BD) method. BD simulation provides a detailed description of the collision stage of the process, accounting for the atomic-scale topography of the protein and the mutual electrostatic interactions. The electrostatic field around the protein is computed by iteratively solving the linearized and full Poisson-Boltzmann (PB) equation on a cubic grid. The rate effect of linearization of the PB equation is thus demonstrated. A realistic two-parameter model of the electron transfer event at collision is employed which is exponentially varying over donor-acceptor distance. Bimolecular rate constants calculated in this fashion are compared successfully with experimental rates in the literature, and the kinetic effect of substituents on the ferrocene is unravelled into steric and electrostatic contributions.

## ENGINEERING SECTION

James Booth, Chair

PREDICTING MONTHLY ELECTRIC ENERGY CONSUMPTION IN SHELBY COUNTY: CHOOSING AN APPROPRIATE FORECASTING METHOD. **William L. Allen\* and Michael L. Daley**, *The University of Memphis, Memphis, Tennessee*. Memphis Light, Gas, and Water Division sells electrical energy to approximately 365,000 customers in Shelby County, Tennessee. Currently, total electric consumption with units measured in gigawatt-hours has been predicted using simple forecasting methods. These annual predictions were further broken down into monthly values. In an effort to achieve more accurate medium-term sales forecasts, three univariate models, simple moving average, exponential smoothing, and Box-Jenkins, were used after separating the consumption data into residential, commercial, and industrial customer classifications. A summary of the analysis indicates that the moving average model proved to be a good predictor for the industrial usage, while the exponential smoothing and Box-Jenkins models both work well with the residential and commercial data.

POROUS ARTIFICIAL WOOD: PROCESSING AND MECHANICAL PROPERTIES. **Jay Paladugula\* and Fyodor Shultov**, *Tennessee Technological University, Cookeville, Tennessee*. A new family of porous artificial wood materials has been developed based on foamed composites from Low Density Polyethylene (LDPE) waste and wood flour, produced by the injection molding (IM) technique. The reground LDPE waste has been mixed with wood flour and the mixture has been foamed using environmentally friendly chemical blowing agents (sodium salts of carbonic acid and poly-carboxylic acids) in a regular IM machine. The final foamed composites have a solid skin texture which gradually transforms into the cellular core zone. The processing parameters were optimized by studying the relationships between the polymer waste/wood waste ratio, blowing agent and other additive contents and the final mechanical and moisture absorption properties. The density and cellular morphology studies were made to understand the composite structure and behavior, and to suggest the mechanisms of foaming action and reinforcement effect.

HEATING AND COOLING LOADS FOR SINGLE-WIDE MANUFACTURED HOMES IN MIDDLE TENNESSEE. **David W. Yarbrough and Gregory J. Andrews\***, *Tennessee Technological University, Cookeville, Tennessee*. The energy efficiency of two single-wide manufactured homes was studied. The two manufactured homes were identical, except that one unit contained the manufacturer's standard package (R-14) of fiberglass batt insulation installed in the roof assembly, while the second unit contained an upgraded insulation package (R-28) installed in the roof assembly. This ten-month study involved the measurement of ceiling heat fluxes and roof cavity temperatures as well as the electrical energy consumption of each manufactured home heat pump/air conditioner system. Air infiltration measurements were made to determine the effective air leakage of the manufactured home units. A computer-based building energy analysis program, DOE 2.1E, was used to predict the energy consumption based on the properties of the construction materials, structural parameters, and weather data. On-site weather data were collected to provide input for the DOE 2.1 simulations and the evaluation of



heat pump performance. In situ thermal resistances of the roof cavity batt insulation were determined from heat flux transducer and thermocouple data. Thermal resistance averaged over 11 months was 17.0 [hr-ft<sup>2</sup>-°F/Btu] for the standard package (R-114) and 23.5 [hr-ft<sup>2</sup>-°F/Btu] for the upgraded package (R-28). These data were compared with laboratory heat-flow-meter thermal conductivity measurements obtained using specimens of insulation, the same as that used in the test homes. The laboratory results were correlated to obtain an equation for thermal conductivity as a function of temperature and density that described the data to within  $\pm 1$  percent. Air infiltration studies show that the two manufactured homes differed by about 3.5 percent in air volume changes per hour. The standard package (R-14) loses 32.1 percent and the upgraded package loses 41.0 percent of the total heat input to the manufactured home because of air infiltration annually.

**WEB-BASED ELECTRONICS ENGINEERING TECHNOLOGY EDUCATION.** *Adel Salama\* and Ashraf Saad, Austin Peay State University, Clarksville, Tennessee and The University of Cincinnati, Cincinnati, Ohio.* The objective of this project is to develop a Web-based instructional framework to improve the student learning process of electronics engineering technology. We propose to develop and implement a framework for computer-based instruction that can serve as a tool for offering Web-based courses. The framework will enable posting of the syllabus, class material, and laboratory assignments over the Web. The laboratory assignments will comprise instructional units that include applet programs written in the universally compatible JAVA programming language. Each unit will require the interaction of the student and will be designed to have a significant impact on student learning by incorporating a computer simulation of key concepts. Each unit also will include a series of practical example problems and exercises to assist students in exploring the concepts being presented. Evaluation of the educational effectiveness of these instructional units is an integral part of the project. Formative evaluation will be used to improve and modify the units based on user response. This technology also will permit students to learn at a self-paced rhythm and will support offering a course using a distance education approach. The proposed framework will be adopted by several electronics engineering technology courses.

**NEW FAMILY OF POLYURETHANE ELASTOMER BASED ON THERMOSETTING FOAM SCRAP.** *Wai K. Law\* and Fyodor Shutov, Tennessee Technological University, Cookeville, Tennessee.* The objectives of this study were to develop a lab-scale compression molding process to produce solid polyurethane (PUR) elastomers based on 100 percent PUR powder from post-consumer PUR foam scrap and study the properties of the elastomers. A non-cryogenic and non-extrusion proprietary Pressure Shear Pulverization process was used to produce fine powder of size less than 1000 microns from high-resilience low-density cold-curing PUR foam waste of various density derived from used car seats. The powder obtained was used to produce elastomers of thickness about 1.5 mm using the compression molding technique without any binder and additives. Optimization of the compression molding process was conducted to obtain the optimal operation parameters. The study showed that the mechanical properties of the elastomers were strongly determined by the initial powder size. The finer the particle used, the higher the mechanical properties. The elastomers generally exhibited similar

water sorption and chemical resistance properties. The study and comparison of the elastomers based on recycled PUR foams, and the commercial one based on virgin raw materials revealed that the former basically possessed the same or slightly higher mechanical properties.

**DEVELOPMENT OF A SUNSPOT TRACKER.** *Jaime R. Taylor, Austin Peay State University, Clarksville, Tennessee.* NASA Marshall's Experimental Vector Magnetograph (EXVM) requires image stabilization over the period of a few minutes. A high speed image motion compensation system (sunspot tracker) is being developed to provide the necessary stabilization. The sunspot tracker consists of two parts, an image motion determination system and an image deflection system. An algorithm has been developed which can determine sunspot motion using only one row and one column of image data. The algorithm is being implemented using two digital signal processing boards, and two CID cameras, one for each axis of motion. Once the image motion is determined, an error signal is sent to the image deflection system. This system consists of an actuator used to move a mirror about one axis (two of these are being developed). Magnetostrictive actuators were chosen over piezoelectric actuators due to their larger driving force and larger range of motion.

**THE STUDY OF THE PULVERIZATION OF POLYURETHANE FOAMS BY PRESSURE SHEAR PULVERIZATION TO BE USED AS FILLER IN FOAMING SYSTEMS.** *Karena L. Swisher\* and Fyodor Shutov, Tennessee Technological University, Cookeville, Tennessee.* We studied the effect of process variables on the size distribution of powder produced by the Pressure Shear Pulverization (PSP) process and the ability of the powder to be incorporated as filler into new foams. Characteristics of the powder were studied using a scanning electron microscope. The powder was added as a filler to a standard foam formulation using minor adjustments in the catalyst levels. The mechanical properties, water absorption, and morphology of the filled foams were tested and compared to the unfilled foam. The (PSP) powder could be incorporated as filler up to 30% by weight of polyol while maintaining the density and characteristics of the unfilled foam.

**INFLUENCE OF CEREBRAL VENOUS FLOW ON CEREBRAL BLOOD VOLUME CHANGES INDUCED BY POSITIVE PRESSURE INHALATION.** *Michael Daley and Charles Leffler, The University of Memphis, Memphis, Tennessee and The University of Tennessee, Memphis, Memphis, Tennessee.* During intact vascular tone and positive pressure ventilation, cerebral blood volume increases during inhalation and rapidly returns to baseline at the onset of expiration. In contrast, during loss of vascular tone induced by deep hypercapnia, changes in cerebral blood volume correspond to changes in arterial pressure. The purpose of this study was to evaluate changes in cerebral blood volume in relationship to cerebral venous flow. In each of six piglets a cranial window was placed and video micrometer recordings were made. Flow in the selected veins increased monotonically from 89 to 102 pl/sec during inhalation and 95 to 112 pl/sec during expiration as mean venous diameter increased with corresponding values of  $40.9 \pm 4.8$ ,  $41.6 \pm 5.7$ ,  $42.8 \pm 4.8$ ,  $43.9 \pm 4.4$ , and  $44.9 \pm 4.5$   $\mu\text{m}$ . The difference in flow between the two phases of respiration remained relatively uniform at  $6.6 \pm 1.5$  pl/sec. For all degrees of cerebral vascular dilation, venous flow was uniformly greater during expiration than during positive

pressure inhalation. As cerebral vascular dilation increased, changes in cerebral blood volume, as indicated by increasing strength of correlation between changes in intracranial pressure and arterial pressure, were increasingly similar to the arterial pressure changes. These results suggest that compressional changes in the cerebral venous vasculature as a consequence of positive pressure ventilation are diminished as cerebral venous flow increases.

**DESIGN OF A SEAWATER ALGAE FILTRATION SYSTEM USING BIVALVE MOLLUSKS.** *William K. Kelly\* and J. Richard Booth, Tennessee Technological University, Cookeville, Tennessee.* The seawater algae filtration unit is part of an overall effort to build a pilot plant to produce shrimp in a controlled, total-recycle, mariculture environment. The Eastern Oyster, *Crassostrea virginica*, and the hard clam, *Mercenaria mercenaria*, feed naturally by filtering algae from seawater. This work should produce a filter that will allow one or both of these mollusks to remove algae from the water and to become a secondary cash crop. To date, this work has produced two filter designs and solved basic flow control problems. Filter effectiveness is measured by light transmittance, and a calibration curve of transmittance versus dry weight per volume is fairly complete. Mollusk waste disposal has been a problem, but a tentative solution has been found. The trays that support the animals are adequate but not optimal. Future work will include improving the current solutions to some of these challenges and optimizing the filtration system to work efficiently with the shrimp production unit.

**SIGNAL ANALYSIS METHODS TO IMPROVE RELIABILITY OF FLOW MEASURES OF CONDENSERS AND BOILERS.** *Heui Seong Lim\* and Michael L. Daley, The University of Memphis, Memphis, Tennessee.* To check the performance and the efficiency of a Rankine cycle, many parameters and measurements such as pressure, water flow, and temperature are used. Accurate condenser and boiler feed pump performance evaluation require extensive instrumentation, data collection, and analysis. The goal of this research project was to develop a signal processing methodology designed to verify the accuracy of flow measures pertaining to: 1) the external source of cooling water on the surface of a condenser, and 2) the boiler feed water. As the first method to satisfy the goal of this project, correlation analysis was developed to evaluate the dynamic error of measured total water flow and theoretical total water flow. A normalized cross-correlation function was used to generate a correlation coefficient as a means of evaluating the strength of similarity between the two signals. As the coefficient approaches unity, the two signals become more identical. As the second method, bias error was calculated to evaluate differences in flow between expected and measured. From the application of these two methods, the accuracy of flow measurements from the condenser and boiler feed pumps can be evaluated.

**STRESSES IN A DENTAL IMPLANT-CONTIGUOUS BONE CONSTRUCT: EFFECT OF IMPLANT GEOMETRY.** *Gladius Lewis, The University of Memphis, Memphis, Tennessee.* An estimated 65% of persons older than 50 years are either totally or partially edentulous, making demand for dental implants very high. Obviously, the success of such implants is inextricably woven with a host of exogenous and endogenous factors. Among the former are the state of the patient's dental bone and the implantation technique, while design and material(s) of fabrication

are the most important in the latter class. The present work focuses on the von Mises stress in various parts of a model of the implant-contiguous bone system and how it is affected by the geometry of the below-the-bone part of the implant post. The finite element analysis method is used, with the loading and constraints being deemed to be appropriate to clinical conditions. Based on the four cases studied, a below-the-bone geometry for the post is recommended.

**MONITORING BRAIN TRAUMA: COMPARISON OF CORRELATION ANALYSIS TECHNIQUES OF INTRACRANIAL AND ARTERIAL PRESSURES.** *Richard Pasley\* and Michael L. Daley, The University of Memphis, Memphis, Tennessee.* Head-injury with traumatic brain injury is a common cause of neurologic dysfunction in the United States. Patients with head-injury tend to develop secondary complications that may include brain swelling, impaired cerebral circulation, and cerebral ischemia. The focus of our work has been to use both laboratory and clinical observations to develop methods to recognize impaired cerebral hemodynamic regulation from an analysis of the intracranial and arterial pressure signals provided by the bedside physiologic monitor. Previously we described a method of correlation analysis which when applied to the intracranial and arterial pressure signals provides an indication of the state of vascular dilation and cerebral venous flow. The technique involves the evaluation of the normalized correlation function of the intracranial and arterial pressure signals. Recently, a neurosurgical research group in Cambridge, England reported the development of a similar method using statistical correlation coupled to the occurrence of very slow oscillations of arterial pressure. The Cambridge method obtains five-second averages of the arterial and intracranial pressure signals over a period of least two to three minutes and then determines the Pearson's correlation coefficient. Using clinically recorded signals the two methods were compared. The results indicate that unlike the correlation method developed in Memphis, the method proposed by the Cambridge group is limited and requires the presence of low frequency arterial pressure waves.

**THE TRANSIENT GAS DIFFUSION IN A CLOSED-CELL FOAM: A NEW APPROACH.** *Phaneendra B. Kondapi\*, J. Richard Booth and David W. Yarbrough, Tennessee Technological University, Cookeville, Tennessee.* The standard solution to determine the transient gas diffusion for constant diffusion coefficients uses Fourier Series solution. These solutions cannot be applied to the conditions where variation in the gas diffusion coefficient occurs. Transient gas diffusion varies with different boundary conditions and initial condition, which affect the local foam density for both constant and variable diffusion coefficients. In order to determine the solution for transient gas diffusion with variable diffusion coefficients, a new approach has been adopted. The diffusion of the components in a closed cellular foam can be modeled as diffusion across cell walls from cell-to-cell through the foam structure. The one-dimensional diffusion equation, with variable diffusion coefficient, neglecting accumulation and depletion of volatile solute in the non-crystalline foam fraction is used to develop the model.

**THE DESIGN, CONSTRUCTION, AND IMPLEMENTATION OF AN AUTOMATED MANUFACTURING WORK CELL.** *Clint Wells\*, Chin-Zue Chen and John Byrd, Austin Peay State University, Clarksville, Tennessee.* We are in the post-mass-pro-

duction era in manufacturing, and flexible automation is a must. In the Computer-Aided Manufacturing (CAM) course at Austin Peay State University, an automated manufacturing work cell was built as the class project. The main attractive feature of the work cell is that it is flexible and it can easily be reprogrammed to produce different kinds of products that match the machinery capabilities. The work cell consists of an Emco F1 vertical CNC mill, with an in-house designed automatic air vise, a Mitsubishi RV-M1 industrial micro-robot, an Allen-Bradley SLC 500 programmable logic controller (PLC), and an in-house designed work stock feeder. The product used for the experiment was a 3.81 by 7.62 cm piece of plexiglass milled with an Austin Peay logo and the Engineering Technology Department Abbreviation, ENGT, along with the year of 97. It was designed on ProCAD/CAM software, and the CNC program was also generated and down loaded to the mill directly. Once the work cell was set up and triggered, the system automatically produced the final product without human operator involvement.

**CALCULATING ALLOWABLE STEAM PRESSURES FOR ANTIQUE STEAM TRACTION ENGINES.** *John W. Blake, Austin Peay State University, Clarksville, Tennessee.* While obsolete by 1930, steam traction engines still operate as star attractions at antique farm equipment shows. To qualify for operating permits from the State Boiler Inspector's Office, the boilers must pass hydrostatic pressure tests. Also, allowable operating pressure calculations using boiler plate thickness measurements from ultrasonic testing in critical areas are now required. The calculations are based on the ASME Boiler and Pressure Vessel Code (BPVC). The locomotive-type boilers and riveted construction used for these machines have largely disappeared in practice; recent BPVC editions do not directly address these boilers. Following the code to calculate operating pressures is a challenging exercise in both mechanical engineering and the study of boiler technology. This presentation will discuss the author's experience in using recent editions of the BPVC, along with earlier sources to calculate maximum allowable operating pressures for these machines.

## ETHICS OF SCIENCE AND TECHNOLOGY

Ruby Prigmore Torrey, Chair

**SCIENTIFIC INTEGRITY IN A RESEARCH ENVIRONMENT: AN OVERVIEW OF ISSUES AND CHALLENGES.** *Stephen H. Stow, Oak Ridge National Laboratory, Oak Ridge, Tennessee.* Scientists are viewed by the public in a rather unique way, being held in high esteem with regard to ethical conduct. We have a tradition to uphold and strict adherence to the principles of scientific integrity is fundamental to our professions. Scientific integrity encompasses everything from the timely sharing of research data with colleagues and proper mentoring of junior staff to correct authorship practices and confidentiality during the peer review process. The issue of scientific misconduct, or fraud, is also included; falsification and fabrication of data and plagiarism of other's work constitute this sin, which often is highly publicized when it occurs. Fortunately, this is rare, but it does occur and it requires sophisticated and experienced attention. Many universities and federal granting agencies have policies regarding scientific integrity and strict guidelines on how to investigate misconduct and apply discipline. In addition, many

disciplinary areas in science and engineering have developed codes of conduct designed to guide students and researchers. For various reasons, certain disciplinary areas are more prone to violations of ethical conduct than are others, and codes of conduct often reflect this variance. Issues that deserve close attention with regard to scientific integrity include the following. How do we teach the principles of this topic to students and professionals? How do we best publicize gross violations of a disciplinary code of conduct? How much can we depend upon science to be "self-correcting" through the peer review process, and others? Through various organizations and publications, teaching and learning materials on scientific integrity are available. The National Academy of Sciences, the American Association for the Advancement of Science, The National Institutes of Health, the National Science Foundation, numerous books and journal articles, and an increasingly larger number of web-sites provide interested persons with background information, guidelines, case studies, etc.

**ETHICS IN THE GEOLOGY PROFESSION.** *D. M. S. Bhatia, Austin Peay State University, Clarksville, Tennessee.* Ethics in the geology profession may have been adversely affected by the stringent EPA requirements, weak standards of registration for geologists and the general abundance of funds available for clean-up. This seems to be particularly true in the environmental industry relative to the mineral or petroleum industry.

**ETHICS IN THE BIOLOGICAL SCIENCES.** *R. H. McCoy, Austin Peay State University, Clarksville, Tennessee.* Should biologists (scientists) be concerned about the ethical (moral) and legal uses of experimental findings and technological advances? Should we be advocates for or against a particular issue? Should we have a state, regional and/or national consortium to "approve" or "disapprove" of a particular issue, such as abortion, euthanasia, and cloning of humans? Is it ethical to perform another "Tuskegee Study;" even in Third World countries; even if the Nuremberg code on research on humans does not negate it; even if the research would help most of mankind by advancing knowledge, techniques and treatments? What are the ethical considerations of the following? 1) Abortion and RU-486, 2) Genetic testing of embryos and fetuses, 3) Is a positive genetic test for some condition (e.g. mutations in BRCA 1 and BRCA 2) a "pre-existing condition" for insurance purposes? 4) Who owns the genetic information about an individual: the individual, the employer, the insurance company or society? 5) Should the state enforce mandatory sterilization for those that are deemed to be "genetically inferior" or that have a gene or genes for a serious genetic abnormality? 6) Our national system for distribution of organs, 7) Should someone with a dangerous infection, e.g. drug resistant tuberculosis, be detained so that antimicrobials can be administered? 8) Should the State intervene when a seriously ill child can be treated but the parents/guardians refuse treatment for religious or other grounds? 9) Is it ethical for physicians to over prescribe antibiotics? 10) The Human Genome Project, 11) Is it ethical to skirt the intent of the law by reporting GNIDs instead of gonorrhea? 12) Should laboratorians perform "off the record" tests such as HIV testing? 13) Is it ethical to use 27% of Medicare benefits for the 5-6% who die each year? 14) Is it ethical to encourage people to die at home to free up medical space and reduce medical costs? 15) What about grade inflation and late withdrawal from classes?

## GEOLOGY AND GEOGRAPHY SECTION

Daniel Frederick, Chair

**GIS AND THE WORLD WIDE WEB.** *James M. McCluskey, Kathleen Cain\* and Tasha Sykes\**, Austin Peay State University, Clarksville, Tennessee. The dissemination of geographic information via the world wide web is now common. Web sites are becoming more sophisticated in their design and content. Oftentimes, geographic information systems (GISs) are used as the primary tool to construct maps and to report spatial information. The number of pseudo GISs web sites, mapping sites that offer overlay capabilities, is increasing. True interactive GIS sites via the world wide web have the potential to vastly increase the number of end users. Austin Peay State University's Tennessee Today and Tomorrow project is an ongoing effort to establish an interactive GIS web site for a wide range of data for Tennessee. A report is made on the progress of the project to date.

**EPA PROPOSED CHANGES IN AMBIENT AIR QUALITY STANDARDS FOR OZONE AND PARTICULATE MATTER: SCIENTIFICALLY CONTROVERSIAL AND UNIVERSALLY UNPOPULAR.** *Robert A. Sirk*, Austin Peay State University, Clarksville, Tennessee. Responding to concerns that photochemical pollution and particulate soot are contributory elements in respiratory health problems, the Environmental Protection Agency has begun to re-examine acceptable levels for ozone and fine particulate matter production under Clean Air Act National Ambient Air Quality Standards. Proposed are stringent new standards for controlling their production and dispersment. Few recently proposed environmental standards have evoked such widespread criticism and outcry from government, the public, and commercial and scientific communities. The presentation briefly examines three key concerns and criticisms. Specifically examined are: (1) questions pertaining to the science behind the proposed standards, (2) doubts of the need for additional regulation of pollutants currently showing long-term patterns of decline, and (3) concerns over the imposition and enforcement of costly air quality maintenance programs.

**OLD NATCHEZ TRACE PROTECTED FROM EROSION BY LEAF MAT IN LEWIS COUNTY, TENNESSEE.** *Richard G. Stearns*, Vanderbilt University, Nashville, Tennessee. The rounded concave shape of the Old Trace, with little extra deepening at the bottom, suggests no erosion since traffic ceased about 1830. More than 10 cm of rain on March 2, 1997 did not disturb leaves, even on steep grades. Trail wear is believed to result from erosion by runoff. The trace probably was so deepened when it was kept bare by feet and hooves, but leaves have accumulated. Most of the mat is whole leaves accumulated for four or more years; the bottom ca. 2 cm is decayed fragments and humus. New fallen leaves are flat until the next summer when they curl. Curl persists until decay weakens them. Humus is cohesive enough to resist erosion, even by water moving faster than retarded flow through the curled leaves. There are places where a mat had accumulated on newer roads, and leaves washed away, but humus remains.

**BURGESS FALLS: A RELATIVELY YOUNG WATERFALL?** *Hugh H. Mills*, Tennessee Technological University, Cookeville, Tennessee. Topographic evidence suggests the course of Falling Water River has changed in the recent geologic past, so that the current location of Burgess Falls is relatively new. The most

striking evidence is the presence of a large cutoff incised meander along a small creek about 1.7 km southwest of Burgess Falls. The relationship between stream length and meander size in this region indicates that only a stream the size of Falling Water River could have made the meander. About 58 m above the meander is a valley that apparently was the course of the river at that time; most of the vertical drop across the Fort Payne Formation must have occurred along that course rather than at the present location of the falls. Cane Creek, a nearby tributary of Falling Water River, apparently captured the river, resulting in abandonment of the older course and establishment of the present course. Only subsequently did the present falls develop.

**A BRACKETED, TIME-SERIES APPROACH TO MODELING THE IMPACT OF FLUVIAL POINT-SOURCE POLLUTION ON LAKES AND RESERVOIRS.** *Gregory S. Ridenour*, Austin Peay State University, Clarksville, Tennessee. To produce a range of possible outcomes for oxygen deficit in the form of a time series, discharge and water temperature were obtained and the hydraulic geometry was determined for two stations along the Sabine River that bracket a hypothetical point source of effluent. Though the model produced a large disparity in the distance downstream at which maximum deficit occurred from the two localities during the winter, the curves diverged at distances exceeding that to the reservoir. The fraction of oxygen demanding waste that remained at the point of maximum deficit was relatively constant annually for one station, but sinusoidal for the other. The curves for maximum oxygen deficit produced by a hypothetical input of effluent paralleled each other quite closely throughout most of the year but diverged sharply during July and August. This change was attributed to the difference in hydraulic geometry. The fraction of oxygen demanding waste that remained in the Sabine River as it entered the reservoir was greatest in the winter and spring, with discharge being about twice as important as temperature in accounting for the difference.

**RECENT DISCOVERIES OF PLEISTOCENE VERTEBRATES IN TENNESSEE.** *Emanuel Breitburg and James X. Corgan*, Tennessee Division of Geology, Nashville, Tennessee, and Austin Peay State University, Clarksville, Tennessee. Six significant Pleistocene vertebrate finds are briefly discussed. Five of the discoveries are unique because they provide either a record of the presence of previously unknown species (*Palaeolama* cf. *mirifica*; Stout-legged llama), the range of species (*Camelops* cf. *hesperternus*; Yesterday's camel and *Odocoileus virginianus clavium*; Key deer), taxonomic abundance (*Platygonus compressus*; flat-headed peccary), or environmental conditions (*Geomys* cf. *bursarius*; plains pocket gopher) during the Pleistocene epoch of Tennessee. The sixth discovery is of particular significance because it is the first late Pleistocene find in Tennessee demonstrating strong evidence that *Homo sapiens* coexisted with and probably hunted mastodons (*Mammot americanum*) more than 13,000 years before the present.

**TRANSPORT AND FATE OF HEAVY METALS ASSOCIATED WITH COAL-PILE LEACHATE, D AREA, SAVANNAH RIVER SITE, SOUTH CAROLINA.** *Daniel Larsen, Mary Katherine Freeman\* and Miles Denham*, The University of Memphis, Memphis, Tennessee (DL, MKF) and Westinghouse Savannah River Site, Aiken, South Carolina (MD). Geochemical interaction between coal-pile leachate and alluvial sediments are being investigated at the D-area coal pile, Savannah River Site, South

Carolina, in order to understand potential mechanisms of in situ metal removal from ground water. A zone of alteration lies directly below the water table and is indicated by extensive brownish-yellow, brownish-orange, and dark red mottles and soil pH values between 3 and 5. Although evidence for dissolution of feldspars and clay minerals is present from X-ray diffraction, the major effect of alteration is precipitation of coatings composed of poorly crystalline iron oxyhydroxides, silica, and Al-Fe-S-K phases. Micron-sized Fe-Cr-Ni spheres that are thought to be remnants of bacteria are dispersed at the base of the most intensely altered zone. Chemical data indicate that Al, Sb, As, Co, Cr, Cu, Fe, Ni, Sc, Th, U, V, and the rare earth elements are enriched in the altered zone compared to background samples.

**STRATIGRAPHY, CLAY MINERALOGY, AND SELECTED GEOCHEMICAL PROPERTIES OF QUATERNARY AND TERTIARY SEDIMENTS FROM FIVE BOREHOLES IN SHELBY COUNTY, TENNESSEE.** *Evan W. Spann\* and Daniel Larsen, The University of Memphis, Memphis, Tennessee.*

Samples recovered from five boreholes in Shelby County were examined to determine the sand, silt, and clay-sized fractions, the mineralogy of the clay size fraction, the percent organic carbon, and the cation exchange capacity. This data will be useful for evaluating contaminant transport from the surface into major aquifers. Known subsurface units are recognized based on sediment texture and clay mineralogy. In general, particle size increases downhole from silt-dominated loess at the surface to sand-dominated fluvial deposits at depth. In samples from loess and modern alluvial deposits, smectite, illite, and kaolinite are the dominant phases, although vermiculite is also present. Kaolinite and illite dominate the clay mineralogy in deeper strata. The percentage of organic carbon present in each sample is variable, but generally decreases with depth. The cation exchange capacity decreases downhole, following the trend of clay percentage.

**CONTROL OF TOPOGRAPHY BY LITHOLOGY IN THE VALLEY AND RIDGE OF EAST TENNESSEE: A COMPUTER APPROACH.** *Scott M. Lucas\* and Hugh H. Mills, Tennessee Technological University, Cookeville, Tennessee.* The Valley and Ridge (V&R) is an excellent locale for studying the relationship of topography and lithology, as many rock units of widely differing resistance to erosion crop out in close proximity. Using a digitized version of the Tennessee state geology map for the V&R, as well as digitized 1:24,000 scale geological maps of selected quadrangles, we explored the correlation between geology and topography using 3-arc second DEMs of and stream DLGs taken from 1:100,000 scale maps. Comparison of geology and DEMs shows that mean relief and slope values distinguish many rock units. Comparison of geology and digitized stream maps show that both mean distance to nearest stream and drainage density (for 2nd and higher-order streams) correlate well with rock type; ridge-forming units show greater mean distances and lower drainage densities.

**USING THE GEOGRAPHIC DISTRIBUTION OF QUARTZ PEBBLES DERIVED FROM THE CAP ROCK OF THE CUMBERLAND PLATEAU TO STUDY LONG-TERM GEOMORPHIC CHANGES ON THE EASTERN HIGHLAND RIM.** *John H. Briggs\*, J. Christopher McMichael\* and Hugh H. Mills, Tennessee Technological University, Cookeville, Tennessee.* Pennsylvanian sandstones on the Cumberland Plateau commonly

have conglomerate facies containing abundant clasts of granule or pebble size. As these rock units once extended over what is now the Eastern Highland Rim, these quartz clasts are ubiquitous on the Rim. However, the abundance of the clasts varies greatly from place to place. This variation may reflect the time since a given location received fluvial gravels from the Cumberland Plateau or Cumberland Escarpment, and thus may help to reveal long-term changes in the courses of rivers on the Rim, and perhaps may even shed light on the way in which the Cumberland Escarpment has retreated. We are making an effort to determine the areal variation in the abundance of quartz clasts by making pebble counts in streams in a study area centered on Putnam County, Tennessee.

## HISTORY OF SCIENCE

Phillip M. Mathis, Chair

**VERTEBRATE PALEONTOLOGY IN TENNESSEE: THE STATUS IN 1990.** *James X. Corgan and Emanuel Breitburg, Austin Peay State University, Clarksville, Tennessee, and Tennessee Division of Archaeology, Nashville, Tennessee.* Thirty-eight vertebrate fossil sites were discovered in Tennessee by 1900. Twenty-nine predate the Civil War. In 1823, John Haywood, a judge, summarized knowledge. In the 1830s the first State Geologist, Gerhard Troost, published new mastodon localities. In the 1850s and 1860s the second geologist, James M. Safford, recorded several new sites parenthetically in geological reports. Most of his finds were fish teeth. In the 1890s Henry C. Mercer of the University of Pennsylvania, began large-scale excavations in Tennessee and collected varied faunas. He published extensively. By 1900 anyone interested in fossil vertebrates knew Mercer's work. Older publications were less known. Some major finds were undescribed. Synthesis was lacking. The 20th century should leave a clearer record.

**THE NODIC FIELD THEORY OF RUDY WECKERING.** *Roy W. Clark, Middle Tennessee State University, Murfreesboro, Tennessee.* From 1935 to 1965 an engineer from Belgium offered to the scientific world his "true finally correct steric atom. . .," which he called the nodic field atom. Weckering's atom model was one in which the electrons were to be considered static, sitting on the nodes of electric and magnetic fields, which placed them in a unique pattern, the electronic nodic field. Static models of the atom are not unknown. G. N. Lewis apparently toyed with such an idea in 1902. The "Lewis pictures" we now draw for students learning the valence rules are static pictures which few chemists interpret literally, but many find useful. The VSEPR theory can be considered a modern and accepted static picture of valence electron arrangements. What sets Rudy Weckering's theory apart from all others is that his ingenious nodic lattice on which he placed the electrons to explain the chemistry of everything, could be scaled down by a factor of 2000 and used to explain nuclear stability and radioactivity. Scaled down even more, Weckering claimed that it also explained the structure of the proton and the neutron. This paper examines some of the chemical predictions of the electronic nodic field.

**NEWTON'S PRINCIPIA: PROPOSITION XI OF BOOK ONE.** *Kevin Ryan, Christian Brothers University, Memphis, Tennessee.* Isaac Newton's *Principia* is probably the most important science

book ever written and, at the same time, among the least read. From the three Books and more than 200 Propositions, one of the most famous is Proposition XI of Book One, which proves that given an elliptical orbit of a moving object, there must be an inverse square force. This Proposition is explained using the methods of J. Bruce Brackenridge and Dana Densmore.

SCIENCE IN THE RENAISSANCE. *W. Renn, Middle Tennessee State University, Murfreesboro, Tennessee.* Acting as the gravediggers of the Medieval world, it may be said that Renaissance man prepared the way for the new age of science. There were considerable obstacles to the development of the scientific method: natural science was still subject to theology; science was chiefly deductive and non-experimental; it was still a time when ideas counted for more than facts. All of this medieval baggage, much of it appendages to Aristotelian thought, would have to be jettisoned. The entire edifice of medieval Christian thought about nature would have to be dismantled and reconstructed before the modern view of science could be achieved. Renaissance specialists proclaimed the right to choose between different authorities or to place experience and experiment above all authority. The dominant attitude of the Renaissance was essentially worldly, confident, secularist, individualistic, and optimistic, which aided the spirit of scientific curiosity. Careful observation was greatly enhanced by the Renaissance artists, Renaissance anatomists reconstructed the scientific understanding of the human body, Plato's precepts were often followed, and pure and applied mathematics were studied with Platonic thought. As a background for Copernicus' work, the Neoplatonists were important. Copernicus did his revolutionary work during the High Renaissance, and its implications would transform physics and theology. The new views and breakthroughs would soon corrode and disintegrate the old medieval world. The Renaissance in Italy prepared the foundations of modern science, which, with the aid of the printing press, would gradually expand into France, Holland, England, and the world.

FIFTY YEARS OF SCIENTIFIC INFORMATION IN EAST TENNESSEE. *Mona H. Raridon, Oak Ridge, Tennessee.* At the end of World War II the Federal Government sought a means of making the results of wartime research available to the scientific community. This effort led to *Abstracts of Declassified Documents*, then *Nuclear Science Abstracts*, and finally the *Energy Data Base*. The history of this work is traced from the days of the Atomic Energy Commission, through the Energy Research and Development Agency, to the Department of Energy.

BIG SCIENCE MEETS LOCAL POLITICS: JOE L. EVINS AND THE END OF PROJECT MOHOLE. *George E. Webb, Tennessee Technological University, Cookeville, Tennessee.* Although an excellent example of "Big Science" because of its focus and scope, Project Mohole's life and death were determined by political considerations. The support of Rep. Albert Thomas (D-Texas) was crucial in the early years of the project, especially after questions began to be raised in the early 1960s about scientific goals, technical requirements, and estimates. Thomas used his position as chairman of the appropriations subcommittee overseeing this project to guarantee continued funding. When Thomas died in early 1966, however, his chairmanship passed to Rep. Joe L. Evins (D-Tennessee), whose political interests and perspectives were very different from those of his predecessor. Primarily concerned with government spending levels, Evins saw

little value in appropriating large sums "to dig a hole." The subcommittee thus recommended no funding for Mohole for fiscal 1967, leading to the cancellation of the project by Congress in August of 1966.

JOHN THOMAS SCOPES AND THE TENNESSEE MONKEY TRIAL: EXHIBIT ONE. *Philip M. Mathis, Middle Tennessee State University, Murfreesboro, Tennessee.* When he arrived in Dayton, Tennessee late in the summer of 1924, John Thomas Scopes could not have anticipated that his name soon would be known nationally and even internationally. But in less than a year, his actions were focal points in a sensational legal test of Tennessee's anti-evolution law, the Butler Act. The textbook from which he purportedly taught is little known, however, except perhaps among academic educationists, barristers, and historians. The text, *A Civic Biology*, by George W. Hunter, was introduced during the trial as Exhibit One. Contents of the text, including specific references taken from court proceedings, are presented and discussed.

## MATH AND COMPUTER SCIENCE SECTION

Dennis Walsh, Chair

THE PROBABILITY THAT A QUADRATIC EQUATION HAS REAL ROOTS. *Dovie Kimmins, Middle Tennessee State University, Murfreesboro, Tennessee.* The probability that the quadratic equation  $ax^2 + bx + c = 0$  has real roots under various restrictions on the coefficients will be explored. Specifically, we will review the derivation of the following well-known results and confirm them with computer simulations. If the coefficients  $a$ ,  $b$ , and  $c$  are real numbers chosen at random from interval  $[-N, N]$ , the probability of real roots is  $(41 + 3 \ln 4)/72$ , which is independent of  $N$ . However if  $a = 1$ , then the probability of real roots is  $1 - (2/3\sqrt{N})$  for  $N \geq 4$ . Thus in the case of  $a = 1$ , as  $N$  approaches infinity, the probability that the roots are real approaches 1. Computer simulations show the results to be similar for the discrete case.

DEFINING THE FACTORIAL OF A MATRIX. *Kevin Shirley, Milligan College, Milligan College, Tennessee.* The factorial of a square matrix is in theory defined using the functional calculus from linear algebra and operator theory. This definition uses the power series expansion of the corresponding single-variable analytic function. However, in the case of the factorial function, this definition is very restrictive as to the types of matrices to which it can be applied, sheds little light upon their properties, and is computationally ineffective. In this work we will give two definitions of the factorial of a square matrix. One will be the most general definition which is possible. This definition can be applied to any matrix that does not have negative integer eigenvalues. It will shed light upon the properties which the factorial of a matrix should possess. We will use a derivation similar to Gauss's derivation for the single-variable factorial function. The second definition will be a computationally effective definition and we will use a derivation similar to Euler's definition of the Gamma function.

HAND PRINTED CHARACTER RECOGNITION USING SEQUENCE COMPARISON TECHNIQUES. *Donald Bullock\*, David Cofer\*, Mark Flowers\*, Frank Hadlock, Aaron Mad-*

**dux\* and Mathew Malone\***, *Tennessee Technological University, Cookeville, Tennessee*. Hand printed character recognition is useful in applications in which data are entered into the computer by scanning handprinted characters or entering the characters via electronic pen. This paper assumes the mode of entry results in little rotation or scale change, but does result in variability as far as slope, length and connectivity. This approach to handprinted character recognition utilizes a notion of string or sequence comparison known as the Damerau-Levenshtein string metric. Consequently, the problem is transformed into one of mapping a character into a linear descriptor sequence which retains sufficient morphological information to serve as a basis for discrimination/classification. The character to linear descriptor mapping is accomplished by horizontal and vertical raster scans, which produce a linear representation capturing information as to number of crossings and run length. Initial results indicate the approach is feasible.

WHEN DO THE COMPACT SUBGROUPS OF A GROUP FORM A RELATIVELY NORMAL LATTICE? **James B. Hart**, *Middle Tennessee State University, Murfreesboro, Tennessee*. A lattice  $L$  is relatively normal provided it has a least element  $\perp$ , is distributive, and satisfies the following condition: Whenever  $a, b \in L$  are incomparable, there exist  $x, y \in L$  such that  $x \wedge y = \perp$ ,  $y \leq a$ ,  $x \leq b$ , and  $x \vee a = y \vee b = a \vee b$ . Relatively normal lattices are an important subclass of distributive lattices which have been studied extensively since the 1950's, both for the elegance of their structure and for their widespread applicability. In this talk, I present a topic which is suitable as a beginning research project for any graduate student interested in group or lattice theory. What conditions guarantee that the compact (finitely generated) subgroups of a group form a relatively normal lattice? The answer turns out to be remarkably simple and has intriguing consequences which can easily lead the student into more advanced study.

STABILITY OF SOLUTIONS OF A CLASS OF NON-LINEAR PLANE AUTONOMOUS SYSTEMS. **Jan C. Zijlstra**, *Middle Tennessee State University, Murfreesboro, Tennessee*. The Lienard equation:  $x'' + f(x)x' + g(x) = 0$  constitutes a class of (systems of) differential equations with important uses for modeling nonlinear phenomena in, particularly, the biological sciences. Stability of solutions of  $x'' + f(x)x' + g(x) = 0$  is investigated by linearization of the equivalent class of autonomous systems around the equilibrium points  $(x_i^*, 0)$  where  $g(x_i^*) = 0$ . A condition for asymptotic stability of the equilibrium points is derived. Dynamic stability for solutions of  $x'' + f(x)x' + g(x) = 0$  is surveyed based on the existence of asymptotically closed trajectories in the Poincare phase plane. Conditions for the existence and uniqueness of these limit cycles are discussed.

IMPLEMENTATION OF AGENT-BASED MANUFACTURING SYSTEMS USING JAFMAS. **Ashraf Saad**, *Austin Peay State University, Clarksville, Tennessee*. JAFMAS is a Java-Based Agent Framework for Multi-Agent Systems. It provides an agent architecture and a five-step generic methodology for the development of multiagent systems (MAS). JAFMAS supports both directed and subject-based broadcast communications. It also provides agents with linguistic and coordination support. Linguistic support is based on speech-act theory. Coordination is modeled as rule-based conversations represented by automat models. JAFMAS is therefore a valuable tool for the develop-

ment and deployment of scalable, fault-tolerant, self-configurable and flexible multiagent systems. To develop a multiagent system, the user needs only extend four of the sixteen Java classes that comprise JAFMAS. We propose to use JAFMAS for the development and implementation of agent-based manufacturing systems. Our research has demonstrated the viability of the agent-based approach for the control and scheduling of flexible manufacturing systems. However, JAFMAS will first need to be augmented by the constructs necessary to measure the performance of the flexible manufacturing systems under consideration.

HAND PRINTED CHARACTER RECOGNITION USING PICTURE DESCRIPTION LANGUAGE. **Steve Barber\***, **Jonathan Campbell\***, **Alan Davies\***, **Frank Hadlock**, **Ronald Perkerson\***, **Chris Shiflett\*** and **Matthew Wilson\***, *Tennessee Technological University, Cookeville, Tennessee*. Hand printed character recognition is an area of computer science which offers labor saving opportunities in many types of computer applications. Problems in character recognition arise due to the vast differences in individual styles of handwriting. This problem is addressed by using Picture Description Language (PDL), a way to express characters as a string of symbols, as a method of representing characters to be matched. Each character must pass through several stages before it can be recognized, including, thinning, filling, vertex location, PDL generation, and most likely candidate generation. By using PDL, each character can be generalized into a string, which is then compared to a library to find the closest match.

SMALL-SAMPLE ESTIMATION OF A POPULATION MEDIAN. **Dennis P. Walsh**, *Middle Tennessee State University, Murfreesboro, Tennessee*. For random samples of size  $n = 10$  through  $n = 40$ , we develop a quick-and-easy interval estimate of the population median. Let  $L$  equal the integer closest to  $.4n - 2$  and  $U$  equal the integer closest to  $.6n + 3$ . We show that the population median will fall in the interval  $[y_L, y_U]$  about 96% of the time, where  $y_k$  denotes the  $k$ th smallest value in the sample. The derivation of the interval is based on the central limit theorem and a linear Taylor approximation of a function of the sample size  $n$ . The exact confidence coefficient  $c_n$  for the interval depends on  $n$  and is calculated with binomial probabilities. We show that  $c_n$  has lower bound 0.9361, upper bound 0.9883, and average value 0.9597, justifying the approximate 96% confidence level attached to the interval.

## MEDICAL SCIENCE SECTION

Al Iglar, Chair

IN VITRO DETERMINATION OF BIOLOGICAL EFFICACY OF SELECTED BORONATED COMPOUNDS FOR NEUTRON CAPTURE THERAPY IN THE HUMAN LUNG CANCER CELL LINE A549. **Thomas E. Byrne**, *Roane State Community College, Harriman, Tennessee*. The purpose of this research was the development of a system for the evaluation of boronated compounds for boron neutron capture therapies (BNCT) in the human lung cancer cell line A549. The determination of biological efficacy was established by the evaluation of survival curves following irradiation with thermal neutrons. In this research the boronated compounds examined were the boron-containing deoxyribonucleoside CDU-4 and the boron-containing

ribonucleoside CN-V-264 and the alpha amino acid LSK 1-38 and the cyclic amino acid m-carboranyl ACBC. A 30 mg  $^{252}\text{Cf}$  source from the Radiochemical Engineering and Development Center at Oak Ridge National Laboratory provided thermal neutrons for this study. A flux of approximately  $2 \times 10^8$  thermal neutrons/cm<sup>2</sup>/second was generated by this source in the sample region. All experiments with thermal neutrons plus boronated compounds displayed a greater cancer cell killing effect than control experiments without boronated compounds. Calculations of nuclear interactions with dose per cell are also reported.

**THE EFFECTS OF UNILATERAL VERSUS BILATERAL CAROTID BODY DENERVATION ON RESPIRATION.** *Jeanne Beals\**, *David O'Drobinak*, *Paul Martino* and *Hubert Forster*, *Austin Peay State University, Clarksville, Tennessee (JB,DO)* and *Medical College of Wisconsin, Milwaukee, Wisconsin (PM,HF)*. Several studies have documented the effects of bilateral carotid body denervation (CBD) on respiration. After bilateral CBD, ventilation while breathing room air will decrease, the level of arterial CO<sub>2</sub> will increase due to this lack of ventilation, and CO<sub>2</sub> sensitivity will decrease. However, very few studies have been done after unilateral CBD. We postulated that after unilateral CBD the one functional carotid body would be able to compensate and the rate of ventilation, the level of arterial CO<sub>2</sub>, and CO<sub>2</sub> sensitivity would be the same as before surgery. To test this hypothesis, four goats were studied, one bilateral CBD and three unilateral CBD. Bloods were drawn while the goats were breathing room air, during hypercapnia, and during hypoxia. These bloods were analyzed to determine partial pressure of arterial CO<sub>2</sub> and O<sub>2</sub>. These data when compiled with data collected on rates of ventilation gave us a good picture of normal breathing and the changes in CO<sub>2</sub> sensitivity. Our data after bilateral CBD did coincide with the decrease in ventilation, increasing levels of arterial CO<sub>2</sub>, and decreased sensitivity to CO<sub>2</sub> seen previously. However, our data were very variable among the unilateral CBD goats. All three goats showed a decrease in CO<sub>2</sub> sensitivity, but two of the three showed a slight increase in resting PaCO<sub>2</sub>. More studies must be done to determine a concise answer because the collected data did not support our hypothesis.

**THE USE OF INBRED RAT STRAINS TO STUDY COMPLEX DISEASE.** *Kim Hodges\**, *David O'Drobinak* and *Allen Cowley*, *Austin Peay State University, Clarksville, Tennessee (KH, DO)*, and *Medical College of Wisconsin, Milwaukee, Wisconsin (AC)*. We have developed an inbred rat strain to study the complex disease of hypertension. In a complex disease such as hypertension, both multiple genes and the environment contribute to the expression of the disorder. Eight hypertensive-inbred lines of rats have been developed. In this study, we are using the cross between the normotensive inbred Brown Norway (BN) and the inbred salt sensitive Dahl rat (DS). These inbred strains are important in many ways: by providing an animal model derived from parental inbred strains with genetically identical background, by rapidly producing a large number of progeny for study, and by allowing the study of arterial pressure and those phenotypes that cosegregate with arterial pressure. The BN and DS (P<sub>0</sub>) are crossed and their offspring (F<sub>1</sub>) are brother/sister mated to generate F<sub>2</sub> generation with a broad spectrum of genotypes and resultant phenotypes. These animals are then studied over an intense three-week protocol in which we measure or calculate over eighty phenotypes to assess a variety of neuroendocrine, renal, and vascular responses. Tissues from these ani-

mals will be genotyped using a total genomic scan approach in which the DNA from each rat will be analyzed using genetic markers that can tag regions of a chromosome. When the genotype data are combined with the phenotype data, we hope to identify those genes that cosegregate with arterial blood pressure.

## SCIENCE AND MATH TEACHERS

Michael Rutledge, Chair

**FOLLOW-UP EVALUATION FOR VIRTUAL WATERSHED SUMMER WORKSHOPS.** *Richard K. Fletcher, Jr.* and *Joseph D. Sharpe*, *Tennessee Technological University, Cookeville, Tennessee*. A follow-up evaluation survey was sent to the 1995 and 1996 participants in a virtual school watershed workshop. Participants were asked to react to a set of Likert type items relating to the five main objectives for the program. Of those who responded, 94.5 percent indicated the workshops had increased their knowledge and awareness of the streams and watersheds of Tennessee. Only 5.6 percent were in disagreement with the item. On the item asking whether they had incorporated the information into their classroom, 84.4 percent agreed. When asked whether they were stimulated to adapt and build on what was presented in their classrooms, 88.9 percent agreed. Participants also indicated they were using skills taught such as E-mail, World Wide Web, temperature, water flow, pollution exercises, field trips, and pH exercises.

**ELECTRONIC CALCULATORS: TO GRAPH OR NOT TO GRAPH.** *Andrea Pryor-Ross\** and *Michael Daley*, *The University of Memphis, Memphis, Tennessee*. The purpose of this study was to clearly identify the positive and negative factors involved with the use of graphing calculators. A survey was developed and administered to 32 high school teachers (math and science) in the Memphis, Tennessee and Shelby County area (both private and public schools). Among the teachers who use the calculators: 1) 18 of 25 listed speed as the greatest advantage of use, 2) 10 of 25 indicated that use of graphing calculators reduces basic understanding of mathematical concepts and 3) 12 of 25 suggested that students become too dependent on the calculators. Most agree that the calculators enable the students to make complicated calculations quickly. However, all agreed that use of the calculator should not substitute for basic understanding of concepts.

**USING PROBLEM-BASED LEARNING TO TEACH A SCIENCE ETHICS COURSE.** *David Ekkens*, *Southern Adventist University, Collegedale, Tennessee*. Issues in Natural Science and Religion is a senior level ethics class required of all biology majors at Southern Adventist University. Previously, the course, taught twice each year with approximately 20 students each term, had been about one half lecture and one half student presentations. When planning for the 1997–98 school year the decision was made to teach it using a Problem-Based Learning (PBL) system. The course adapted nicely to a PBL approach since the class deals with ethical and philosophical problems. The course is based on a series of thirteen problems (some real, some hypothetical), or one problem per week. The problem is assigned on Monday and the students write a series of objectives: things they think they will need to investigate in order to solve the problem. Each student then investigates one or more of these



objectives and reports his/her findings to the teacher via Internet. The teacher acts as a clearinghouse, compiling the information and emailing it back to all members of the class. Wednesday's class is spent discussing the preliminary results. Students often report on other things that may have been missed in the original objectives, which need to be added. During Friday's class, we attempt to summarize the problem and its solution. A short paper on the problem is due the following Monday. Student reactions to the class are presented.

**MATHCOUNTS: A UNIQUE TOOL TO DEVELOP INTEREST IN MATHEMATICS AMONG SEVENTH AND EIGHTH GRADE STUDENTS.** *Richard Raridon, John Whealton, and Amy Reed. Oak Ridge National Laboratory, Oak Ridge, Tennessee (RR, JW) and Robertsville Middle School, Oak Ridge, Tennessee (AR).* MATHCOUNTS is a nationwide math coaching and competition program that is sponsored by the National Society of Professional Engineers, NASA, and several companies and foundations. Students in grades 7 and 8 have the opportunity to compete in local, state, and national competitions. Prizes are awarded at all levels. There are four students on a team and they compete individually as well. Currently, there are eight chapters in Tennessee, most of which send two teams to the state competition. In 1997, 58 students from 7 schools competed in the Oak Ridge Chapter. The authors are the team coaches at Robertsville Middle School, which has been participating in the competition for more than 10 years. This is the fifteenth year of national competition. Last year 350,000 students participated nationally. The students are presented with challenging problems, many of which have multiple steps. Some problems are recursive and require inventing theorems. Some problems cannot be done on a calculator, short of Mathematica, such as finding the last digit of 2 to the 90th power.

**CREATING A CLASSROOM WITHOUT WALLS.** *Deborah C. Clark, Middle Tennessee State University, Murfreesboro, Tennessee.* A growing number of educators are discovering that the World Wide Web is an exciting and unique teaching tool. However, many are skeptical of its use citing concerns that students will be tempted to use the Web rather than traditional sources of information such as the library. I have found that the World Wide Web is a unique tool that can be used by educators to "create a classroom without walls." In a genetics and social issues class, I use the World Wide Web to evaluate public perceptions and opinions about controversial issues in the field such as the use and applications of cloning. In my introductory genetics class, the World Wide Web is used to collect and analyze data. And in a non-majors biology course, the World Wide Web provides students the opportunity to explore other aspects of, and issues associated with, the biological topics discussed in class. Specific examples of how the Web can be used in the classroom will be discussed.

**BACCALAUREATE DEGREE REQUIREMENTS OF BIOLOGY MAJORS AT COLLEGES AND UNIVERSITIES IN TENNESSEE.** *Michael L. Rutledge and Danny L. Bryan, Middle Tennessee State University, Murfreesboro, Tennessee, and Cumberland University, Lebanon, Tennessee.* Thirty-seven colleges and universities in the state of Tennessee offer bachelors degrees with majors in biology. These institutions differ in size, mission, and academic requirements. An analysis of the degree requirements of biology majors reveals a diversity among the programs

with respect to the total number of credit hours in biology required, the nature of the introductory biology coursework, specific required biology courses, and required coursework in chemistry, geology and mathematics.

**TEACHING THE CONICS, SOME OLD AND NEW IDEAS.** *Nell Rayburn, Austin Peay State University, Clarksville, Tennessee.* Textbook treatments of the conic sections at the precalculus and calculus level frequently define ellipses in terms of the sums of distances to foci and hyperbolas in terms of the differences of distances to foci. The following alternative characterizations are well known but are usually ignored by texts at this level. An ellipse is the locus of points equidistant from a circle and a point inside the circle. A hyperbola is the locus of points equidistant from a circle and a point outside the circle. Wax paper constructions of the envelopes of tangents to the conics make use of this characterization and have appeared in the educational literature. The availability of good geometry software has made it possible to animate these constructions and to make the beauty of the conic sections more accessible to our students.

**"SURVIVING SCIENCE": A SELF-HELP PROGRAM FOR THE SCIENCE STUDENT.** *Michelle M. Cooper\* and Nancy G. Morris, Volunteer State Community College, Gallatin, Tennessee.* The open-door policy of the community college brings in students who do not necessarily possess the study skills needed for success in science coursework. The "Surviving Science" program was developed to address that need. The program began as a 5-part seminar series designed to present to students the tools required to survive science. That series was condensed to a 1-hour video now in post-production, and an accompanying information booklet. The seminar met small success; participation was low, but satisfaction and improvement in science grades among participants was high. Now in evolution are peerled study groups in general chemistry and majors' general biology. Future plans include recruitment of peer tutors, the implementation of a practicum course to train tutors, and study group offerings for a wider variety of science courses.

**STUDENT-DESIGNED LABS: HOW TO GENERATE UNDERSTANDING OF THE SCIENTIFIC PROCESS IN AN INTRODUCTORY BIOLOGY COURSE.** *Linda T. Collins, University of Tennessee at Chattanooga, Chattanooga, Tennessee.* There has been an explosion of information in introductory biology courses in the last generation. This vast increase in the amount of information can easily result in an introductory course that barely skims the knowledge necessary for a basic understanding of biological concepts. As a consequence, students have little comprehension about the process that scientists use to formulate these concepts. One means to improve this problem is to offer labs that are designed and performed by students. A lab exercise that works well is the investigation of yeast fermentation of various substrates. Students have access to a number of variables, e.g., different substrates, substrate concentration, yeast concentration, temperature and pH. They formulate a hypothesis and design an experiment to test the hypothesis. They collect data and draw a conclusion. We use a very simple procedure that has good results. A 15 ml test tube is filled with a yeast suspension and substrate solutions. The test tube is inverted into a 25 ml test tube. Fermentation is measured by the size of a bubble of CO<sub>2</sub> in the inverted test tube. Students learn about hypothesis formation, the importance of a control, data analysis, and sometimes

the failure of experimental design. Because they follow the same process that scientists use, they gain insight about how experimental results are organized into the body of a scientific concept. As a result, they can be more critical about new scientific information.

**SCIENTIA: A STUDENT-OPERATED ELECTRONIC JOURNAL AS AN EDUCATIONAL EXPERIENCE.** *John D. DuBois, Phillip M. Mathis, Judith N. Hankins, John D. Clark\* and K. Burton Harvey\**, Middle Tennessee State University, Murfreesboro, Tennessee. *Scientia*, *The Journal of Student Research*, launched in the spring of 1997 at Middle Tennessee State University (MTSU) highlights research efforts and achievements of students in the College of Basic and Applied Sciences. *Scientia* allows students to experience first-hand the operations of a professional scientific journal. Students fill the positions of editor, associate editor, Web site manager, and the editorial board, with representation from each of the nine departments in the College, along with the University Honors Program. Governance and promotion of *Scientia* are the responsibilities of the board of faculty facilitators representing each department and chaired by the Dean of the College. Manuscripts describe the results of graduate or honors thesis research, undergraduate independent research, department-sponsored student projects, or classroom-generated projects. The student editorial board reviews manuscripts and makes recommendations to the editor. The editor makes the decision to accept/reject each manuscript submitted. The student Web site manager maintains the Web site and posts accepted manuscripts. One issue each year is devoted to the abstracts of the Graduate and Undergraduate Research Symposia held each spring at MTSU. The address for the *Scientia* Web site is: <http://www.mtsu.edu/~scientia>.

**THE WESTERN AS AN EDUCATIONAL EXPERIENCE IN BIOLOGY.** *J. Watson\*, N. Chim and A. Farone*, Middle Tennessee State University, Murfreesboro, Tennessee. The Western blot immunoassay (or "Western"), also known as an enzyme-assisted immunoblotting assay is a procedure that employs specific antibody reactions to detect the presence of proteins in a sample. This technique can be an especially useful tool to immunologists and has many applications in research and industry. We have utilized this laboratory technology in the immunology course at MTSU to serve as a model for undergraduates to gain research experience as well as providing an opportunity for them to present their work to the other undergraduates. Students began by researching the Western blot technique, then conducted the procedure with instructor supervision. The goal of the experiment was to reproduce a classic immunology experiment demonstrating that antibodies consist of protein chains of two different sizes (a light and a heavy chain). After the first trial run the students were responsible for working out the details of the procedure and preparing a presentation for the immunology laboratory.

**A SERIOUS LOOK AT SILLY PUTTY.** *Debora A. Zartman\*, Gary D. White and Judith M. Bonicamp*, Middle Tennessee State University, Murfreesboro, Tennessee. Manufacturers use "smart pigments" in many older products to rejuvenate consumer interest. Changeable Silly Putty is one of the many toys containing a pigment that changes color with temperature. We controlled the sample temperature using a water bath, a peristaltic pump, and copper tubing on which the Silly Putty sample was placed. The temperature of the sample was monitored by a therm-

istor. The color change in Changeable Silly Putty occurs at 28–32 C and is completely reversible due to the presence of liquid crystals. We have also tracked the color change with a TLC scanner, using data collected on the changes in absorbance over time to analyze the kinetics of the color change. A variety of Silly Putty samples were subjected to microscopic analyses (fluorescence and visible). Thermographic profiles acquired via differential scanning calorimetry help to explain the visible changes on a molecular level.

## MICROBIOLOGY

Anthony Newsome, Chair

**PHASE VARIATION OF TYPE 1 FIMBRIAE IN *ESCHERICHIA COLI*.** *Jon H. Lowrance, Rebecca Downs\*, David L. Hasty and Evgeni V. Sokurenko*, Lipscomb University, Nashville, Tennessee (JHL, RD) and *The University of Tennessee, Memphis, Memphis, Tennessee (DLH, EVS)*. *Escherichia coli* are a major cause of urinary tract infection and type 1 fimbriae are important in virulence because they lead to adhesion to urinary tract tissues. Expression of type 1 fimbriae is subject to phase variation controlled by an invertible 314 bp element upstream from the *fimA* gene and can be detected by agglutination of yeast. Orientation of the *fimA* promoter within this invertible element is one factor determining whether bacteria are fimbriated (ON) or non-fimbriated (OFF). In this study, we optimized polymerase chain reaction (PCR) conditions for primers flanking the invertible element and demonstrated the feasibility of PCR analysis of phase variation. *HinfI* restriction analysis of PCR products from various strains indicated that the switch can be identified as "ON" and/or "OFF." Interestingly, yeast agglutination tests of various strains did not correlate with PCR analysis.

**THE ISOLATION OF WHEY-DEGRADING MICROORGANISMS USING AN AGAR MEDIUM.** *Kristina Fusco\* and John M. Zamora*, Middle Tennessee State University, Murfreesboro, Tennessee. Whey is the watery material that is removed from cheese during cheese production. It is also a large waste product of the dairy industry that is expensive to break down into usable components. The purpose of this study was to create a solid medium for the isolation of whey-degrading microorganisms. Raw whey, soil, and dairy sludge samples were plated onto four different types of solid media: tryptic soy agar, Sabouraud dextrose agar, minimal salts agar containing sterile filtered whey, and minimal salts agar containing autoclaved whey. Tryptic soy agar was used for the enumeration of bacteria. Sabouraud dextrose agar was used for the enumeration of yeast and molds. Both the sterile filtered and the autoclaved whey agar were used for the enumeration of organisms that could grow on these agars. Statistical analysis indicated a difference among the four agars. There was no difference between the sterile filtered and the autoclaved whey agar. Several known organisms were plated onto the autoclaved and sterile filtered whey agar to determine the selectivity of the media.

**INCIDENCE OF *SALMONELLA* IN TURTLES AT THE DUNBAR CAVE STATE NATURAL AREA, CLARKSVILLE, TENNESSEE.** *Don C. Dailey*, Austin Peay State University, Clarksville, Tennessee. Human disease from *Salmonella* as the result of contact with reptiles is well documented. Pet turtles can serve as

carriers of *Salmonella* and cause infection in man, especially children. In 1975, a ban was placed on the sale of turtles with a carapace diameter <10.2 cm. Studies with captive turtles have documented the carriage of pathogenic strains of *Salmonella*. Few studies have investigated the carriage of *Salmonella* by natural turtle populations. A mark-recapture study was used to investigate the prevalence of *Salmonella* in a natural turtle population at the Dunbar Cave State Natural Area. During the summer of 1997, 242 turtles were sampled. Of these, 77 turtles were recaptured and cultured at least once. Approximately 40% of the turtles were positive for *Salmonella*. Sporadic intermittent carriage of *Salmonella* was documented. Data demonstrate that a single culture specimen is not adequate in estimating the carriage of *Salmonella* by turtles.

#### THE DETECTION OF *CAMPYLOBACTER JEJUNI* IN MILK.

**James Nokes\* and John M. Zamora**, Middle Tennessee State University, Murfreesboro, Tennessee. *Campylobacter jejuni* is a small Gram-negative bacterium that can be found in raw milk as well as raw meat and poultry. This organism is believed to be the major cause of gastroenteritis in the United States. The conventional isolation procedure requires that *C. jejuni* be cultured on a highly selective medium at 42 degrees C for four to six days. Polymerase chain reaction (PCR) can also be used to detect the presence of *C. jejuni* DNA. This technique requires a very small sample and is completed in four to five hours. Our purpose is to compare the conventional method of isolation to PCR using both raw and pasteurized milk. Pasteurized milk was inoculated with *C. jejuni*. The sample was diluted and plated on *C. jejuni*. An aliquot of the sample was saved for PCR. The sample was then pasteurized. After pasteurization, the sample was diluted and plated on *Campylobacter* agar. The DNA of the sample before and after pasteurization was amplified using PCR. The amplified DNA samples were compared using electrophoresis. The inoculated milk was positive for *C. jejuni* with over 1000 cfu/ml. After the inoculated milk was pasteurized, no colonies were observed. The amplified DNA of *C. jejuni* was detected before and after pasteurization. This indicates a possible problem with using PCR to detect *C. jejuni* in pasteurized milk.

#### DETECTION OF *HELICOBACTER PYLORI* IN SEWAGE BY THE POLYMERASE CHAIN REACTION.

**Michelle Stinson\* and Stephen M. Wright**, Middle Tennessee State University, Murfreesboro, Tennessee. It is estimated that nearly 25 million individuals in the United States are afflicted with peptic ulcers. The first suggestion that a bacterium might be associated with ulcers was made in 1982. Since that time, a wealth of information has accumulated demonstrating that *Helicobacter pylori* may indeed colonize the gastric mucosa and be associated with ulcer formation over time. As many as 80% of individuals with stomach ulcers are colonized with *H. pylori*. In developing countries lacking adequate wastewater or drinking water treatment facilities, the incidence of *H. pylori* infection in the entire population has been reported to be as high as 80%, suggesting contaminated water as a source of infection. This study evaluated raw sewage for the presence of *H. pylori* nucleic acid by the polymerase chain reaction and probe hybridization to specific nucleotide sequences. We report the detection of *H. pylori* sequences in sewage, demonstrating a potential means of transmission.

#### EVALUATION OF RIBOSOMAL PROTEIN L9 GENE SEQUENCE CONSERVATION AMONG CLASSES WITHIN

SUBPHYLUM VERTEBRATA. **Chad Welsh\*, Sam O'Dell\* and Chad Brooks\***, Middle Tennessee State University, Murfreesboro, Tennessee. Ribosomal proteins carry out similar functions in many different organisms. Similarity between disparate organisms implies some ribosomal proteins have been conserved throughout evolution. Conservation of the ribosomal protein L9 (rpL9) gene, coding for a protein associated with elongation factor EF-2, among different organisms in the subphylum Vertebrata has not been fully determined. A fragment of the rpL9 gene sequence was amplified by the polymerase chain reaction using known sequences specific for the human gene. Amplification products were evaluated by gel electrophoresis and dot blot hybridization to determine whether the selected rpL9 sequence was conserved among animals in different classes. We report that the results of both the gel electrophoresis and the dot blot hybridization indicate that the rpL9 sequence was conserved in some of the animals tested but not in all.

### PHYSICS AND ASTRONOMY SECTION

Douglas Durig, Chair

#### RESPONSE FUNCTION OF THREE MIRROR CAVITY.

**Ling Jun Wang**, The University of Tennessee at Chattanooga, Chattanooga, Tennessee. The exact response function of three-mirror optical cavity is obtained in terms of the beam wavelength, the cavity lengths and the indices of refraction of the two cavities between the three mirrors. The theory shows that an auxiliary external cavity can be devised to select a single mode of a diode laser, a useful technique to cope with the mode-hopping problem associated with semiconductor lasers. The formulation developed here is especially useful in designing and analyzing the performance of a semiconductor laser with such auxiliary external cavities.

#### MESOPHASE STRUCTURE OF COLUMNAR LIQUID CRYSTALS.

**M. Sarkar\* and N. Spielberg**, Tennessee State University, Nashville, Tennessee, and Kent State University, Kent, Ohio. The mesophase structure of pyramidal columnar liquid crystal hexaalkanoxytribenzocyclononene is being investigated by x-ray powder transmission diffractometry. We compare the results of this sample with results published for the other homologues. The number of diffraction lines found is much larger than for the other homologues. The x-ray diffraction pattern of the biaxial phase of the homologue II-10 is interpreted on the basis of 2-dimensional oblique lattice. For this II-9 compound very high values of Miller Indices are needed in 2-dimensional interpretation. Unlike the homologues II-10, 12, 13 and 15, the axial parameters and angles of this sample are different at different mesophase temperatures, even though the oblique symmetry remains unchanged. When 3-dimensional indexing is made, longitudinal order between adjacent columns may be happening because the number of diffraction lines is decreasing with increasing temperature. Further measurements at higher temperatures within the mesophase would help explore this possibility further.

A COMPARISON OF THE LONGITUDINAL AND TRANSVERSE IMPEDANCE SPECTRA OF FROG MUSCLE MEASURED IN VIVO. **R. L. McMillen\*, N. J. Berner and F. X. Hart**, The University of the South, Sewanee, Tennessee. The real

and imaginary components of the electrical impedance of a frog gastrocnemius muscle were measured, in-vivo, over the frequency range 1 to  $10^6$  Hz. The spectra were collected with a Solartron 1260 Impedance Analyzer. The two electrodes were nickel-plated steel sewing needles with a diameter of 0.60 mm and a separation of 1.3 cm. The interelectrode region was regarded as a series combination of an electrode interface and muscle. Each region was modeled as the parallel combination of a resistance and a constant phase-angle element. A series resistance was added to represent high frequency trans-membrane conduction. The model parameters were obtained through a complex, non-linear least squares fit to the experimental spectra. As expected, the muscle impedance parameters were higher for the electrodes directed perpendicular to the muscle fibers (transverse) as compared to directed parallel to the fibers (longitudinal).

**AMUSEMENT PARK PHYSICS.** *Henry Kuhlman and Randolph S. Peterson, Southern Adventist University, Collegedale, Tennessee, and The University of the South, Sewanee, Tennessee.* Each spring the PHYSICS Alliance of Chattanooga (PAC) sponsors a Physics Day at the Amusement Park at Lake Winnepesaukee in Chattanooga, Tennessee for area high school physics students. Students take measurements on the following four rides: 1) Merry-Go-Round, where centripetal acceleration can be measured, and the Coriolis force can be observed by rolling tennis balls, 2) Roller Coaster, where the conservation of energy and centripetal force are studied, 3) Swinging Pirate Ship, which demonstrates pendulum motion, conservation of energy, and centripetal force, and 4) Ferris Wheel, where the observed centripetal force is compared to calculated centripetal force. Typical student results will be presented.

**UNFILTERED CCD IMAGES OF SUPERNOVA 1997BS IN NGC 2637 (M66): PREDISCOVERY IMAGES AND FOLLOW-UP OBSERVATIONS.** *Douglas T. Durig and Shane Z. Terry\*, The University of the South, Sewanee, Tennessee.* On April 16, 1997, it was announced through the Central Bureau of Astronomical Telegrams that a supernova had been discovered in NGC 3627 by R. R. Teffers, C. Y. Peng, and A. V. Filippenko from the University of California at Berkeley, and M. W. Richmond of Princeton University. They used an automated telescope called KAIT to observe the galaxy on April 15 UT and discovered 17th magnitude Supernova 1997bs. As part of an ongoing student project to observe and hopefully discover supernova, Shane Terry and I had taken a CCD image of M66 on April 10 UT. I later found that NGC 3627 was M66. I reviewed our earlier image of April 10 and noticed a very dim object at the location of the supernova at magnitude  $18.25 \pm 0.4$ . We thus began a study of the light curve for the supernova as it began to fade.

**DETERMINATION OF FIBER ORIENTATION IN PAPER USING POLARIZED LIGHT SCATTERING.** *Paul Rivera\* and Patricia G. Hull, Tennessee State University, Nashville, Tennessee.* An experimental method for determining the orientation of microscopic fibers in paper using polarized light scattering is presented. The method is based on measurements of the Mueller matrix elements S22 and S23 as functions of scattering angle, elements that theory show to be strong predictors of fiber orientation. A paper sample is mounted in the light scattering instrument on a goniometer that provides a precise orientation of the sample with respect to the scattering plane. In theory, the maximum signal in S22 occurs when the greatest number of fi-

bers in the sample are aligned perpendicular to the scattering plane. The algebraic sign of S23 indicates the direction of tilt of the fiber from the perpendicular. The fiber orientation in the paper is obtained by examining the graphs of S22 and S23 vs. sample orientation angle.

**PREDICTING THE ORIENTATION TENDENCIES OF A COLLECTION OF MICROSCOPIC FIBERS.** *Patricia G. Hull, Tennessee State University, Nashville, Tennessee.* A theoretical method for predicting the orientation of a collection of microscopic fibers using polarized light scattering is presented. The Mueller matrix elements S22 and S23 as functions of scattering angle are shown to be strong predictors of fiber orientation. Calculations of S22 and S23 using the couple-dipole approximation are made at a fixed scattering angle for cylinders and ribbons of sizes and indices of refraction comparable to cellulose fibers in paper. The calculations show that the maximum signal occurs in S22 when the greatest number of fibers is aligned perpendicular to the scattering plane. Therefore, the fiber orientation is defined as this angle. S23 predicts the direction of tilt from the perpendicular. The degree of orientation is defined by a function of the minimum and maximum intensity measurements in S22 as the fiber sample is rotated through a  $360^\circ$  cycle. A function is selected that varies between zero and one. The degree of orientation is equal to 0 for a randomly oriented collection of fibers and 1.0 for a collection of fibers all aligned in one direction.

**WFPC2 OBSERVATIONS OF STAR CLUSTERS IN THE MAGELLANIC CLOUDS II. THE SMALL MAGELLANIC CLOUD INTERMEDIATE-AGE POPULOUS CLUSTER NGC 416.** *Kenneth J. Mighell, Ata Sarajedini and Rica Sirbaugh French\*, KPNO/NOAO, Tucson, Arizona, and Middle Tennessee State University, Murfreesboro, Tennessee.* We present our analysis of archival Hubble Space Telescope Wide Field Planetary Camera 2 observations in F555W ( $\sim V$ ) and F450W ( $\sim B$ ) of the intermediate-age populous star cluster NGC 416 in the Small Magellanic Cloud galaxy. We used published photometry of two other SMC populous star clusters, Lindsay 1 and Lindsay 113, to investigate the age sequence of these three star clusters. We determined the following ratios of  $\text{age}_{\text{NGC416}}/\text{age}_{\text{L1}} \approx 0.73 \pm 0.05$  and  $\text{age}_{\text{L113}}/\text{age}_{\text{L1}} \approx 0.52 \pm 0.09$ . These age ratios provide absolute age estimates of  $6.6 \pm 0.5$  Gyr and  $4.7 \pm 0.8$  Gyr for NGC 416 and Lindsay 113, respectively, assuming that Lindsay 1 is 9 Gyr old. Metallicities of  $[\text{Fe}/\text{H}] = -1.44 \pm 0.12, -1.35 \pm 0.08, -1.24 \pm 0.11$  dex, and reddenings of  $E(B-V) = 0.08 \pm 0.03, 0.06 \pm 0.02$  and  $0.00 \pm 0.02$  mag for NGC 416, Lindsay 1, and Lindsay 113, respectively, were determined simultaneously using the method of Sarajedini & Layden (AJ 113:264, 1997). The determination of accurate (relative) ages for the intermediate-age populous clusters in the Small Magellanic Cloud (e.g. via deep main sequence photometry) would allow the  $d_{(B-V)}$  method of Sarajedini, Lee, & Lee (ApJ 450:712, 1995) to be extended to ages significantly younger than 7 Gyr. The extended  $d_{(B-V)}$  method could prove to be a very useful age diagnostic for future studies of the intermediate-age metal-poor stellar populations in nearby Local Group galaxies where accurate main-sequence turn-off photometry at  $M_V \approx +4$  mag is currently not possible or practical.

## ZOOLOGY SECTION

Larry Latson, Chair

THE *YUGUS BULBOSUS* SPECIES COMPLEX OF THE SOUTHEASTERN UNITED STATES (PLECOPTERA: PERLODIDAE). **Charles H. Nelson**, *The University of Tennessee at Chattanooga, Chattanooga, Tennessee*. Currently, the genus *Yugus* is composed of two species, *Y. arinus* and *Y. bulbosus*. However, close examination of collected material indicates that the latter species consists of three distinct forms. Descriptions of the two new species and redescrptions of the presently recognized species are provided and a cladistic analysis of the genus is undertaken.

THE MICROSCOPIC ANATOMY AND PHYSIOLOGY OF THE PROTONEPHRIDIAL SYSTEM OF *ASPLANCHNA PRIODONTA* (ROTIFERA). **Karen L. McGlothlin**, *The University of the South, Sewanee, Tennessee*. *Asplanchna priodonta* is a large, predatory rotifer which has been collected from freshwater lakes and ponds worldwide. As with most freshwater organisms, the cells, tissues, and body fluids of *A. priodonta* are of a higher osmotic concentration than the surrounding medium. In order to maintain its internal environment at this constant higher concentration, the rotifer must osmoregulate and maintain specific ion balances, presumably by virtue of a protonephridium. Minimally, a protonephridium consists of a proximal terminal cell, a protonephridial tubule, and a distal nephridiopore which opens to the exterior. In addition, the system of *A. priodonta* includes a contractile bladder which collects fluid and periodically discharges its contents to the exterior. Transmission electron microscopy (TEM) was used to describe the anatomy of the terminal organs, protonephridial tubule and contractile bladder of *A. priodonta*. Physiological experiments were conducted to help elucidate the function of this system.

MOLECULAR ANALYSIS OF EUTARDIGRADES AND HETERO-TARDIGRADES. **Diane R. Nelson and James R. Garey**, *East Tennessee State University, Johnson City, Tennessee, and University of South Florida, Tampa, Florida*. The phylum Tardigrada consists of over 700 species in two major classes: Heterotardigrada and Eutardigrada. To clarify the phylogenetic relationships of genera within the phylum, we analyzed a nearly complete 18S rRNA sequence of a heterotardigrade (*Echiniscus viridissimus*) and two eutardigrades in the Order Parachela (*Thulinia ruffoi* and *Macrobotus areolatus* species group). We also obtained previously published sequences from GenBank for *Hypsibius sp.* and *Macrobotus hufelandi* species group (Parachela) and *Milnesium* (Order Apochela). Both Neighbor-Joining and Maximum Parsimony phylogenetic trees were consistent with each other and with previously published phylogenies based on morphological characters. The molecular phylogenies support the hypothesis that: 1) tardigrades are monophyletic, 2) within the phylum, heterotardigrades are the most basal, and 3) *Milnesium* (Apochela) is basal to other eutardigrades (Parachela).

THE PAIRED STREAM APPROACH TO MONITORING FOR AQUATIC POLLUTION: DO REFERENCE STREAMS FADE? **Joseph R. Schiller, S. W. Hamilton and Mack T. Finley**, *Austin Peay State University, Clarksville, Tennessee*. Numerical indices of community structure and function, i.e. metrics are used to assess water quality in streams. The Biotic Index, one such met-

ric, for Clear Creek was compared to a reference stream, Hamstring Creek, in a bioassessment of the Illinois River in northwest Arkansas. Clear Creek was not polluted compared to the reference stream. This conclusion is valid only if the reference stream itself is not polluted. Two earlier macroinvertebrate surveys of Clear Creek were examined to see if average pollution tolerance of these streams has changed. No time trend in the biotic index of Clear Creek is obvious. However, differences in sampling methods and taxonomy between the three studies compromise the comparisons. The earliest survey, 1949, includes a very pollution sensitive mayfly genus not reported from later surveys of Clear Creek. The biotic index of the Ephemeroptera taxa in Clear Creek is lower than for Spring Creek, Oklahoma, a similar Ozark stream in the Illinois River watershed. However, differences in the level of taxonomic identification and range of species reported in the two streams limit the usefulness of comparisons. Although the biotic index of Ephemeroptera taxa in Spring Creek is higher than in Clear Creek, almost 25% of the Spring Creek species are very sensitive to pollution. This discrepancy illustrates a conservative bias of family biotic indices compared to biotic indices calculated at the species level of taxonomy.

CITIZENS LEARNING ENVIRONMENTAL AWARENESS NETWORK (C.L.E.A.N.) WATER: A STATEWIDE VOLUNTEER MONITORING PROGRAM. **Tim Thompson and Linda Harris-Young**, *Nonpoint Source Pollution Program, Tennessee Department of Agriculture, Nashville, Tennessee and Motlow State Community College, Tullahoma, Tennessee*. The Tennessee C.L.E.A.N. WATER Program is a program developed by the Tennessee Department of Agriculture's Nonpoint Source (NPS) Pollution Program to promote citizen involvement in learning about nonpoint source pollution and how to monitor and protect Tennessee's water resources. C.L.E.A.N. WATER provides local community groups and schools hands-on experience in learning about, monitoring, and protecting local water resources. C.L.E.A.N. WATER brings together citizens, schools, businesses, and government at the grass-roots level to take an active role in promoting environmental stewardship of water quality in your community. The C.L.E.A.N. WATER Program was developed to include everyone, and includes different activities that vary in intensity of work. The activities are: Stream Walk, Storm Drain Stenciling, Stream Clean-Up, Level I and II Water Quality Monitoring, and a Restoration Project activity. The C.L.E.A.N. WATER Program realizes that citizen volunteers have different interests and concerns about water quality, and that not all citizen volunteers will participate in the same activity. Volunteer groups may decide to implement only one activity, and then build on that later, or they may choose to do more than one activity. By participating, volunteers can promote environmental stewardship of their local water resources, enhance education of others through demonstrating their results, and empower a community to increase its long-term capacity to deal with water quality issues. It is important to remember that water is re-used and recycled, so we all need to work together to protect Tennessee's water resources.

THE MOSQUITOES OF FORT CAMPBELL (DIPTERA: CULICIDAE). **James P. Moore**, *Austin Peay State University, Clarksville, Tennessee*. A survey of the mosquito fauna of the Fort Campbell Military Reservation (Montgomery County, Tennessee, and Christian County, Kentucky) was conducted from 10 May 1996 to 9 August 1997. A total of 351 larval and 117 adult

mosquito collection sites were sampled in the most comprehensive mosquito collection effort on the installation since the United States Army began mosquito surveillance in 1953. A total of thirty-nine species of mosquito were identified, including new installation records for fifteen species. The survey was limited to the 50 km<sup>2</sup> cantonment area, straddling the Tennessee-Kentucky state boundary. The survey area included administrative buildings and housing areas, wooded areas, swamps, rivers and streams, open fields, lakes and ponds, and outdoor recreation areas. Larval collection methods included dipper, siphon and direct pours. Adult collection methods included Centers for Disease Control light traps (incandescent white light and fluorescent ultraviolet light), as well as testing, landing, and biting captures using a mechanical aspirator. Based on installation records of collections dating from 1953, and current geographical species distribution maps for North America, an additional twelve species were expected, but were not located during the survey. A comparison was made of the effectiveness of adult collection methods for monitoring certain pestiferous species (*Aedes triseriatus*, *Aedes vexans*, *Culex restuans*, and *Psorophora ferox*). This survey points out the continued need for a comprehensive mosquito surveillance program, including larval sampling, at Fort Campbell in order to evaluate the potential for arthropod-borne disease and justify the dispersal of pesticides in the environment.

ASSESSMENT OF NATIONAL MARINE FISHERIES SERVICE LONGLINE CRUISES FROM 1954 TO 1996: A PRELIMINARY REPORT. *Lisa M. Jones and Diane R. Nelson, East Tennessee State University, Johnson City, Tennessee.* Due to greater fishing effort, the number of sharks taken in directed and non-directed fisheries has increased in recent years. The demand for shark meat, fins, and cartilage, as well as a larger bycatch in the tuna, swordfish, and shrimp fisheries, has resulted in more sharks being taken from the ocean. Combined with problems in assessing the shark stocks due to their unique life history strategies, this increase in shark take has led to an effort to obtain abundance and distribution patterns in order to institute effective management plans. Databases from the National Marine Fisheries Service, Southeast Fisheries Science Center, Pascagoula Mississippi, Facility, are therefore being analyzed for information on several species of sharks. The databases, which contain shark catch and bycatch records dating back to 1952, will be used to examine these population trends over time in the United States Gulf of Mexico.

THE EFFECTS OF ELECTROMAGNETIC FIELDS ON THE SWIMMING AND FEEDING BEHAVIOR OF *ICTALURUS PUNCTATUS* (SILURIFORMES: ICTALURIDAE). *Michael D. Phillips, William H. Wade, II\* and Willodean D. S. Burton, Austin Peay State University, Clarksville, Tennessee.* The behavioral effects of short-term Electromagnetic Field exposure on the passively electroreceptive Channel catfish (*Ictalurus punctatus*) are not well known. This experiment tested the Channel catfish swimming behavior response to food stimulus in the presence of an electromagnetic field. Two experiments were conducted between 1 March 1997 and 2 April 1997, using 92 and 192 fish respectively. Fish swimming behavior was assessed on the basis of the time required for each fish to complete an 8-foot maze in the presence of varying Electromagnetic Field levels. The data indicate a link between Electromagnetic Field strength (specifically the time-varying 60hz magnetic field component), and in-

creased maze completion time. Statistical analysis (ANOVA, F-Test, and t-Test) with an alpha of 5% ( $\alpha = 0.05$ ) indicated that the null hypothesis ( $H_0$ ) of no effect could be rejected. Thus, near power lines, which cross shallow water sources, fish behavior in swimming and food procurement may be adversely affected. Additionally, the observed disturbance may not be limited to channel catfish, since many other organisms use similar electroreception and geolocation apparatus to acquire resources for survival. The possibility exists that these behaviors may lead to an artificial selection process, reducing the gene pool for the organisms with well-adapted electroreceptive apparatus.

A COMPARISON OF DISINFECTED AND UNTREATED TRAPS FOR SAMPLING SMALL MAMMAL POPULATIONS. *Theresa J. Cross\*, Aaron W. Reed, Brandon T. Rutledge, Benjamin R. Laseter, Shannon A. Maris and Cedric N. Doolittle, The University of Memphis, Memphis, Tennessee.* In 1993, an outbreak of hantavirus pulmonary syndrome (HPS) focused attention on the presence of hantaviruses and their rodent vectors in the United States. Concerns exist about field biologists contracting HPS and related diseases from trapping activity. Guidelines provided by the Centers for Disease Control and Prevention (Atlanta, Georgia) recommend traps that have contained captured rodents be disinfected prior to placement in the field. However, treatment of traps with disinfectant could negatively influence trap success. Such influence has not been thoroughly examined. Therefore, we tested for differences in trap success of small mammals using disinfected and untreated traps. In this comparison, Sherman live traps were treated with a bleach solution before being placed in the field at three locations in Tennessee and one in Oklahoma. The work included 2,542 trap nights with 76 captures in disinfected traps and 68 captures in untreated traps. A t-test revealed no significant differences between the two groups ( $p = 0.8636$ ). Thus, treatment of traps with bleach prior to placement in the field had no negative effects on trap success.

POPULATION ABUNDANCE OF THE APPALACHIAN COTTONTAIL IN EASTERN TENNESSEE. *Benjamin R. Laseter\* and Michael L. Kennedy, The University of Memphis, Memphis, Tennessee.* Density was assessed for a population of Appalachian cottontail rabbits (*Sylvilagus obscurus*) using mark recapture techniques during spring of 1996 and 1997. The study was conducted in Carter, Monroe, and Unicoi counties within the Cherokee National Forest of extreme eastern Tennessee. Using program CAPTURE when appropriate, estimates of abundance ranged from 0.80 individuals per ha to 0.04 individuals per ha during the periods sampled. Results are discussed in light of previous studies of this species.

TAXONOMIC ASSESSMENT OF THREE SPECIES OF PEROMYSCUS IN TENNESSEE. *Aaron W. Reed\* and Michael L. Kennedy, The University of Memphis, Memphis, Tennessee.* Cranial and external measurements were taken from genetically identified deer mice (*Peromyscus maniculatus*), white-footed mice (*P. leucopus*), and cotton mice (*P. gossypinus*) to assess the taxonomic relationships of the species in Tennessee based on morphologic features. Univariate and multivariate statistical procedures were employed in the assessment. Using five characters (greatest length of skull, nasal length, post palatal length, diastemal length, and tail length) in a discriminant function analysis, 100% of the individuals examined were correctly classified.

Three characters (greatest length of skull, basionasal length, and toothrow length) were useful in distinguishing *P. gossypinus* from the other species.

**DENSITY ESTIMATION OF A RED SQUIRREL POPULATION (*TAMIASCIURUS HUDSONICUS*) IN EASTERN TENNESSEE.** *Richard T. Stevens\* and Michael L. Kennedy, The University of Memphis, Memphis, Tennessee.* Density was assessed for a population of red squirrels (*Tamiasciurus hudsonicus*) using mark-recapture techniques (modified Lincoln-Peterson, program CAPTURE) during winter and spring of 1996 and winter of 1997. The study was conducted on a forested site in the Tellico Ranger District, Cherokee National Forest, Monroe County, Tennessee. Using the program CAPTURE, estimates of abundance ranged from 0.0 (no animals captured) to 1.8 individuals per ha during the three seasons sampled. Results are discussed in light of previous reports of density for this species.

**HOME RANGE AND HABITAT UTILIZATION OF WHITE-TAILED DEER IN WESTERN TENNESSEE.** *John R. Ouellette\*, Devlin S. Fung and Michael L. Kennedy, The University of Memphis, Memphis, Tennessee.* Habitat composition of female white-tailed deer (*Odocoileus virginianus*) was assessed from the annual home range of radiocollared animals. The study was conducted on the Milan Army Ammunition Plant in Carroll and Gibson counties, Tennessee. Using Geographical Information Systems, the percent composition of six possible habitats was ascertained for the annual estimates of 50% and 95% minimum convex polygons. Results are discussed in relation to the animals life history and previous literature.

**MONITORING OF LARVAL AMPHIBIAN SURVIVORSHIP AND DEVELOPMENT AND CORRELATION WITH FECAL BACTERIA LEVELS IN SULPHUR FORK CREEK WATERSHED, ROBERTSON COUNTY, TENNESSEE.** *Lillian F. Barber\*, Heidi J. Semrau\*, Cindy L. Taylor, Don C. Dailey and Mack T. Finley, Austin Peay State University, Clarksville, Tennessee.* An ongoing study is being conducted on the water quality of the Sulphur Fork Creek Watershed, Robertson County, Tennessee. Survivorship and development of caged larval amphibians, and the densities of fecal coliform (FC) and fecal streptococci (FS) were monitored. Water samples were collected monthly during May through September, 1996, and again in 1997, from which the fecal bacteria were enumerated. While ground water was found to be of good quality, surface waters exceeded Environmental Protection Agency standards for recreational contact. In conjunction with bacteriological investigation, an amphibian study was conducted at a single site in 1996 (Blue Spring). Further study of the correlation between amphibian population decline and environmental contaminants at two spring sites and two stream sites using *Gastrophryne carolinensis* and *Rana clamitans*, was completed in 1997. Survivorship was higher at the stream sites than the spring sites, but reduced compared to controls.

**INFLUENCE OF ACID MINE DRAINAGE ON WATER QUALITY AND FISH POPULATIONS IN A CUMBERLAND PLATEAU STREAM.** *Jeannie Long\*, Mark Schorr and Rob Mottice, The University of Tennessee, Chattanooga, Chattanooga, Tennessee, and Tennessee Aquarium, Chattanooga, Tennessee.* North Chickamauga Creek, a Cumberland Plateau stream in Southeastern Tennessee, has been impacted by acid mine drain-

age (AMD) from abandoned coal mines. We designed a two-year study (1996-97) to assess the effects of AMD on stream water quality and fish populations in the plateau region of North Chickamauga Creek. Fish were collected using electroshockers and hoop nets in impacted (pH < 5.5) and reference reaches (pH > 6.0). Seven fish species (mostly centrarchids and syprinids) were observed in reference reaches versus three species (mostly centrarchids) in impacted reaches. No fish were observed in reaches with pH values < 4.5. Total fish abundance was greater ( $P < 0.01$ ) in reference reaches versus impacted reaches. Green sunfish *Lepomis cyanellus*, ages 1-3, grew faster ( $P < 0.05$ ) in reference reaches versus impacted reaches. Preliminary results of this study document the adverse effects of coal mine drainage on stream fishes and provide a benchmark for AMD-remediation projects.

**ACID MINE DRAINAGE AND ITS EFFECTS ON PHYSICO-CHEMICAL CONDITIONS AND SALAMANDER POPULATIONS IN A CUMBERLAND PLATEAU STREAM.** *Mary Jane Middelkoop\*, Tiffany Watts\* and Mark Schorr, The University of Tennessee, Chattanooga, Chattanooga, Tennessee.* Acid mine drainage (AMD) from abandoned coal mines has polluted an estimated 18 miles of streams in the Cumberland Plateau region of North Chickamauga Creek, Tennessee. We investigated the potential effects of AMD on stream water quality and aquatic salamander populations in the North Chickamauga Creek system. Salamanders were collected by kick-sampling with a 500  $\mu$ m mesh dip net and electroshocking at impacted sites (pH < 5.6) and reference sites (pH > 6.2), May to July 1996. Dusky salamander *Desmognathus fuscus* (about 89% of total) and total salamander abundance (all species) was lower ( $P < 0.05$ ) at impacted sites versus reference sites regardless of the sampling method. Dusky salamander abundance directly correlated with pH ( $r = 0.99$ ;  $P < 0.001$ ) and inversely correlated with the aluminum concentration ( $r = -0.82$ ;  $P < 0.10$ ). Preliminary findings from this study emphasize the negative effects of acid pollution on stream-dwelling salamanders and provide baseline data for AMD-abatement projects.

**PRELIMINARY EVALUATION OF CONSTRUCTED WETLANDS AS MITIGATION SYSTEMS FOR ACID MINE DRAINAGE IN THE NORTH CHICKAMAUGA CREEK WATERSHED, TENNESSEE.** *Katherine Channell\* and Mark Schorr, The University of Tennessee at Chattanooga, Chattanooga, Tennessee.* Approximately 18 miles of plateau streams in the North Chickamauga Creek watershed, Tennessee, have been degraded by acid mine drainage (AMD) from abandoned coal mines. Two experimental treatment systems (constructed wetlands) have been installed below two acidic drainages (mean pH = 3.3) from surface and/or underground mines. Our study addresses the potential of constructed wetlands for improving water quality (pH > 6) in the North Chickamauga Creek system. Surface measurements of pH and discharge were taken at AMD-influent and wetland-effluent sites, January-December 1996. Preliminary assessments of the two constructed wetlands indicate that influent discharges of acidic mine water exceeded the functional capacity of both systems (no substantial improvement in pH), except during low-flow periods in July-August when mean pH values increased from 3.0 (influent) to 6.3 (effluent). These preliminary findings suggest that structural modifications to the two existing wetlands are needed to improve their effectiveness in treating AMD.

THE AMPHIBIANS AND REPTILES OF DUNBAR CAVE STATE NATURAL AREA, MONTGOMERY COUNTY TENNESSEE. **Kevin C. Fitch\*** and **A. Floyd Scott**, *Austin Peay State University, Clarksville, Tennessee*. We sampled the amphibians and reptiles of Dunbar Cave State Natural Area (Montgomery County, Tennessee) from September 1996 through October 1997. Terrestrial sampling involved hand collecting, sight and audible identification, and terrestrial drift fences with pit and funnel traps. Aquatic sampling employed nylon hoop nets. Selected abiotic data were collected and related to seasonal changes in herpetofaunal activity. Sixteen species of amphibians (5 salamanders and 11 frogs and toads) and 18 species of reptiles (6 turtles, 2 lizards, and 10 snakes) were documented. All were species already known from Montgomery County, and none were species listed by state or federal authorities as endangered, threatened, or otherwise in need of special attention. However one species (*Hyla gratiosa*, Barking Treefrog), known historically from the area but not encountered by us, is currently listed "special concern" and "deemed in need of management" by state officials. The potential for its continued existence should be considered along with the other herpetofauna in future management planning.

CONSERVATION OF THE HERPETOFAUNA AT ARNOLD AIR FORCE BASE. **Brian T. Miller**, **John W. Lamb** and **David Z. Bynum**, *Middle Tennessee State University, Murfreesboro, Tennessee (BTM)*, and *Arnold Air Force Base, Tullahoma, Tennessee (JWL, DZB)*. Arnold Air Force Base (AAFB) formed a cooperative agreement with The Nature Conservancy of Tennessee in 1992 to identify, on AAFB lands, rare flora and fauna, including the herpetofauna. AAFB comprises ca. 15,800 ha and lies in the Eastern Highland Rim physiographic province of south-central Tennessee. General field collecting techniques were used to survey low lying forests subject to seasonal flooding, dry forested slopes, old fields, intermittent and permanent streams,

and a reservoir. Fifty-seven species were identified, including six species listed as in need of special protection by state or federal agencies (*Rana capito*, *Hyla gratiosa*, *Ambystoma talpoideum*, *Hemidactylium scutatum*, *Pituophis melanoleucus*, and *Ophisaurus attenuatus*). Significant extensions or clarifications of distributions were noted for *R. capito*, *Ambystoma texanum*, *Nerodia flavigaster*, *Virginia valeriae*, and *Thamnophis sauritus*. The high level of biodiversity found prompted the formation of a ten year cooperative agreement between AAFB and T with The Nature Conservancy of Tennessee to continue inventory efforts and to develop management recommendations for monitoring, conserving, and enhancing rare, threatened, or endangered species.

TIGER HUNTING IN TENNESSEE (DIPTERA: CULICIDAE: *Aedes albopictus*). **James P. Moore**, *Austin Peay State University, Clarksville, Tennessee*. A survey of Tennessee's 95 counties was conducted to determine the presence of *Aedes albopictus*, the Asian tiger mosquito. This survey, primarily of tire habitats, established the first record of *A. albopictus* in 87 Tennessee counties and confirmed the continued presence of the species in eight counties with previously reported infestations. Mosquitoes of twelve different species or species complexes were collected during the period July to October 1997. Fifty-one percent of the larval collection sites yielded *A. albopictus* as the only culicid inhabitant. *A. albopictus* shared the habitat with other species of mosquito in 31 percent of the larval collection sites. *A. albopictus* and *A. triseriatus* were cohabitants of only six percent of the larval collection sites. No specimens of *A. aegypti* were observed. Despite an expected photoperiod-induced egg diapause at <13.5 hours daylight, hatches of *A. albopictus* larvae were observed at 11.8 hours daylight in Montgomery County, Tennessee. Many questions yet remain regarding the dispersal, distribution, and potential for disease transmission in North America.