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**A NEW DISTRIBUTIONAL RECORD OF *Notropis topeka* (TELEOSTEI:CYPRINIFORMES)
FROM THE MISSISSIPPI RIVER
DRAINAGE IN MISSOURI**

(Received November, 1995; accepted for publication May, 1996)

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Abstract: The known distribution of the Topeka shiner (*Notropis topeka*) in Missouri was restricted to the Missouri River drainage. A collection in 1987 from a Des Moines River tributary represented the first documented record from the Mississippi River drainage in Missouri. The record is one of only a few new localities for the species, which has declined in other northeastern Missouri basins and across the state.

Key Words: *Notropis topeka*, *Etheostoma spectabile*, Mississippi River, Des Moines River, Chariton River, distribution, endangered species.

The Topeka shiner (*Notropis topeka*, Gilbert)¹ is one of only a few fishes endemic to prairie regions in the Great Plains and Central Lowlands provinces of the central United States. It seems to be an intolerant species that does not persist in degraded habitat. Topeka shiner habitat occurs in our nation's foremost agricultural areas. Habitat degradation in these areas has reduced the species' range (Minckley and Cross, 1959; Pflieger, 1990; Tabor, 1993). Hence, *N. topeka* has been designated as "of special concern" to "endangered" in the states of Iowa, Kansas, Minnesota, Nebraska, and South Dakota. In Missouri, the species status has recently changed from "status undetermined" to "endangered" because recent extensive surveys by Dr. William Pflieger, Greg Gelwicks, and the author (all of the Missouri Department of Conservation) revealed declines at historical sites and few new localities for this species (MDC, 1994; Gelwicks, 1996). Tabor (1993) recommended that *N. topeka* be considered for Category 1 (C1) listing under the Endangered Species Act. The species was recommended for endangered status, but a moratorium on ESA listings by the U.S. Fish and Wildlife Service kept it off the list. *Notropis topeka* is currently listed as a C1 species under the ESA.

Notropis topeka has historically been found in the James and Sioux River systems in South Dakota and Minnesota, the Niobrara and Platte River systems in Nebraska, the Kansas and Arkansas River systems in Kansas, the Grand and Missouri River systems in Missouri, and primarily the upper Des Moines River

¹-Mayden and Gilbert (1989) showed that *N. topeka* was a junior synonym of *Moniana tristis* Girard, 1856, a name unused since its proposal. I follow the recommendation of the International Commission on Zoological Nomenclature in retaining the specific epithet *topeka* (ICZN, 1995).

system in Iowa (Gilbert, 1980). The majority of collection records for *N. topeka* are from the Missouri River drainage. *Notropis topeka* has been collected from the Iowa, Cedar, Des Moines, and Fox River basins in Iowa, and the Wapsipinicon river in Minnesota in the Mississippi River drainage.

Notropis topeka has been declining in abundance and distribution across its range (Tabor 1993). Since 1990 in Missouri, *N. topeka* has been found at only 14 of 71 historical and 6 of 66 new localities sampled (Gelwicks, 1996). Populations in the Chariton River drainage in north-central Missouri have markedly declined (Hrabik, unpublished data). I extensively sampled upper Chariton River basin streams in Putnam, Schuyler, Sullivan, and Adair counties in 1990. I collected only one *N. topeka* and a possible *N. topeka* x *N. dorsalis* hybrid from Dog Branch (Putnam County; nel/4, S17, R16W, T65N), a small direct tributary to the Chariton River. Voucher specimens are being held in ichthyological collections at the Open River Field Station. Populations of *N. topeka* from the Des Moines River drainage also appear to be declining. Although Harlan and Speaker (1987) note that *N. topeka* was common where it was found in Iowa, both Harlan and Speaker (1987) and Tabor (1993) show or list several historical sites where it has not been recently collected. In southeastern Iowa, *N. topeka* was collected from a Des Moines River tributary in Lee County (during the last 20 years) and from Fox River in Van Buren County (over 20 years ago). Recent attempts to collect *N. topeka* from those localities were unsuccessful (Vernon Tabor, personal communication). The drainage in the Lee County site has been extensively modified by erosion and flood control dams. The Wapsipinicon River population may be extirpated and it appears that *N. topeka* is restricted to the Missouri River drainage in Minnesota, as Anderson et al. (1977) were unable to collect *N. topeka* in southern Minnesota.

In Missouri, *N. topeka* was widely distributed from the Hundred-and-Two River in the northwest, to the Chariton River in the north-central, and to Missouri River tributaries in the central portion of the state, all in the Missouri River drainage. No known collections have been found in the Mississippi River drainage in Missouri.

On 3 September 1987, Ken Brummett and Kyle Reno collected 87 specimens of *N. topeka* from Cedar Creek, Clark County, Missouri (nw1/4, S6, R7W, T66N). Cedar Creek is a tributary to the Des Moines River; therefore, this collection represents the first time that *N. topeka* has been collected from the Mississippi River drainage in Missouri. Cedar Creek was sampled in only one location, approximately 2.4 km above its confluence with the Des Moines River, so it is not known if the population inhabited the entire length of the creek. Other species collected in association with *N. topeka* and their relative abundances are given in Table 1.

Eleven other species were found in association with *N. topeka*, all composing a common assemblage for streams of similar size in northeastern Missouri. The only exception was *Etheostoma spectabile*, which is uncommon (but not rare) in extreme northeastern Missouri. Incidentally, this collection of *E.*

spectabile was possibly the first ever from the Des Moines River drainage (Bruner, 1980; Harlan and Speaker, 1987).

Table 1. Relative abundance of species collected in association with *Notropis topeka* from Cedar Creek, Clark County, Missouri, on 3 September 1987.

Species	Number Collected	Relative Abundance as a Proportion of Total Catch
<i>Campostoma anomalum</i>	5	0.005
<i>Cyprinella lutrensis</i>	183	0.167
<i>Notropis dorsalis</i>	82	0.075
<i>Notropis topeka</i> *	87	0.079
<i>Pimephales notatus</i>	109	0.099
<i>Pimephales promelas</i>	95	0.087
<i>Semotilus atromaculatus</i>	10	0.009
<i>Catostomus commersoni</i>	6	0.005
<i>Ameiurus melas</i>	89	0.081
<i>Lepomis cyanellus</i>	417	0.380
<i>Etheostoma nigrum</i>	12	0.011
<i>Etheostoma spectabile</i>	1	0.001

* voucher specimens were deposited at the University of Nebraska State Museum (ZM-03565)

Cedar Creek is a 6.0-kilometer long, second-order direct tributary to the Des Moines River. It begins on an upland plateau and intermittently flows through the hills along the Des Moines River. Riparian vegetation at the 185-meter collection site consisted primarily of annual grasses and herbs and trees, i.e., *Salix* and *Populus* spp. Aquatic vegetation consisted only of planktonic algae. Headwater substrate was comprised primarily of silt and sand but most of the stream's length had a bedrock bottom. Pools appear to be maintained by seepage and are apparently cool as the water temperature was 15°C (~5 degrees cooler than most surrounding streams in the area). The maximum depth of pools at the collection site was 0.45 meter. Pools in the vicinity of the collection site averaged 2.1 meters wide and 45 meters long. The water was generally clear, as the bottom of pools could be seen.

Notropis topeka habitat in Cedar Creek is similar to that described in the literature (Cross, 1967; Pflieger, 1975; Minckley and Cross, 1959), and seems to be

undergoing degradation that may be detrimental to the species. Tabor (1993) listed sedimentation and eutrophication as the most likely actions impacting populations of *N. topeka*. These processes may be the greatest threat to the survival of the Cedar Creek population. Most of Cedar Creek flows through pasture and some evidence existed of elevated plankton concentrations and bank erosion caused by trampling of livestock. Sedimentation, eutrophication, and stream channelization are problems in extreme northeastern Missouri watersheds (e.g., Hrabik, 1992). If *N. topeka* is indeed intolerant of habitat degradation as postulated, then my data suggests that stream habitat and water quality in northeastern Missouri has deteriorated. Based on distributional data, *N. topeka* probably occurred along the entire length of the Des Moines River and may have occurred in the Fox River basin in Missouri. No populations are currently known to exist in either basin from southeastern Iowa (Harlan and Speaker, 1987; Vernon Tabor, personal communication), or the Fox River basin in Missouri (Hrabik, 1992). The Cedar Creek population may be the last surviving in the lower Des Moines River basin.

A similar decline has been documented in the Chariton River basin (Hrabik, unpublished data; Gelwicks, 1996) where its scarcity and possible hybridization suggests the population is barely persisting and may soon become extirpated.

Acknowledgements: Randy Haydon assisted with collections and identifications. Dr. William L. Pflieger reviewed an early draft of the manuscript. An anonymous reviewer provided recent information on the taxonomic and conservation status of *Notropis topeka*. I wish to thank the administrations of the Long Term Resource Monitoring Program and the Missouri Department of Conservation, Fisheries Division, for their support in preparing the manuscript.

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MONITORING APHIDS IN SCOTCH PINE CHRISTMAS TREE PLANTINGS

(Received May, 1995; Accepted for publication, July, 1996)

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Abstract: Aphids are occasional pests for Christmas tree growers in southwest Missouri. In 1992, aphids were detected in high enough numbers to cause loss of sales of this product. In 1993, aphid populations were present in the spring and early summer but not in late summer, fall or winter. Because of the time of occurrence, there was no economic loss. A device to easily monitor aphids in Scotch pine Christmas trees is described. Materials needed to construct the sampling device are: a pint container, a 30.5 cm ruler, a 10.2 cm diameter disc coated with petroleum jelly, a small metal screw, tape and a rubber band.

Key Words: Aphididae, Christmas trees, *Pinus sylvestris* L., sampling device

Introduction

Christmas tree growers need timely information regarding invertebrate pest problems in their plantings. In all cases, growers in southwest Missouri have no systematic procedure for assessing invertebrate organisms on Scotch pine, *Pinus sylvestris* L., Christmas trees. This is particularly true for small invertebrate pests that easily conceal themselves in the numerous needles of Scotch pine trees such as aphids (Aphididae). Aphids suck juices from the tree's branches, shoots and needles. Infested trees may lose needles, attract secondary pests and make the trees unsuitable for sale (Benyus, 1983). Examining individual needles on these trees for aphids can be extraordinarily time-consuming. Therefore, aphids infesting Scotch pine Christmas tree plantings go undetected until the populations attain such large numbers that visible damage or nuisance problems "magically" appear overnight.

A system needs to be fashioned that will allow a grower to monitor his crop. If a monitoring system is implemented and good record keeping is practiced religiously, the knowledge that growers can acquire through their own observations may be quite remarkable. With this in mind, the following device was constructed and a procedure implemented to help detect small invertebrates associated with Scotch pine Christmas trees.

Methods

The device (Fig. 1) was constructed as follows: a 4x5/8 pan head sheet metal screw was inserted into the middle of a 30.5 cm wooden ruler 0.6 cm from one end. Next, the wooden ruler was inserted into the lid of a pint container to the 4x5/8 sheet metal screw. The cup portion of the container had four 0.6 cm semicircular notches removed from its base. These notches provided slots for a

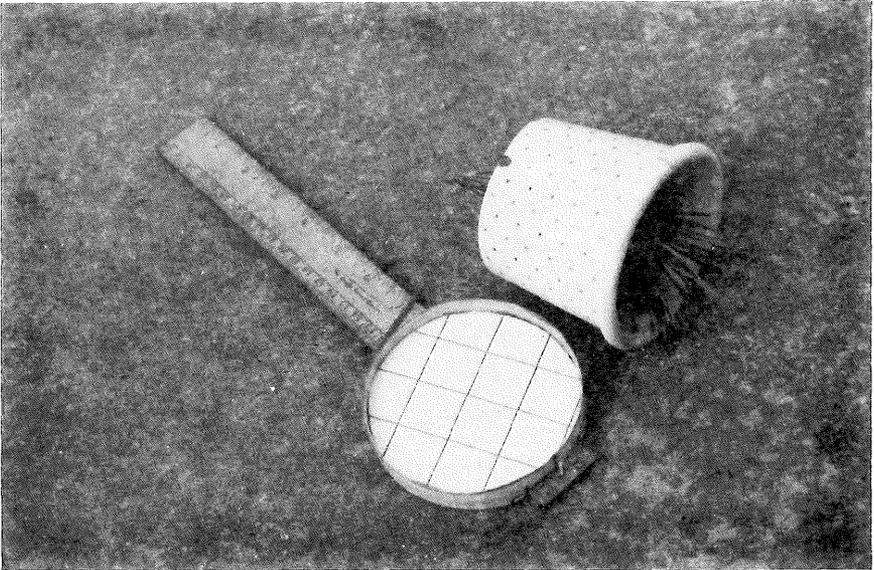


Fig. 1. Sampling device with a 10.2 cm branch sample inserted in the cup of the pint container.

rubber band that held the cup against the lid when the device was operated. A 6.4 cm square piece of 3M transparent sealing tape was attached to the outside bottom of the cup. In the bottom of the cup, two 3.8 cm slits were cut that intersected one another. Prior to operating the device for each branch sample, a 10.2 cm diameter disc coated with petroleum jelly with a 2.5 cm square grid pattern, petroleum jelly side up, was inserted into the lid. The rubber band encircled the ruler and was loosely in place until the device was used.

To operate the device, a 10.2 cm branch sample was cut from the south half of the tree. This branch sample was inserted into the cup cavity and pushed through the 3.8 cm slits approximately 2.5 cm. The cup portion of the container with the branch sample inside was closed with the pint lid containing the petroleum jelly-coated disc. The rubber band was slipped down the ruler and brought over the outside of the cup and looped over the opposite end of the ruler. The device was now used like a hammer, sharply rapping it fifteen times against the plexiglass rectangle pictured in Fig. 2. Once this was completed, the rubber band was released, the cup removed, the branch sample discarded and the coated disc removed and placed in an empty plastic box. The interior of the pint container and the outside bottom of the cup were wiped clean with a paper towel before taking the next sample.

A carrier (Fig. 2) was used to facilitate handling of the 26 samples taken at each location. A nylon belt was attached to the carrier so that it could be strapped to the waist of the person sampling the trees. A fanny pack was attached to the

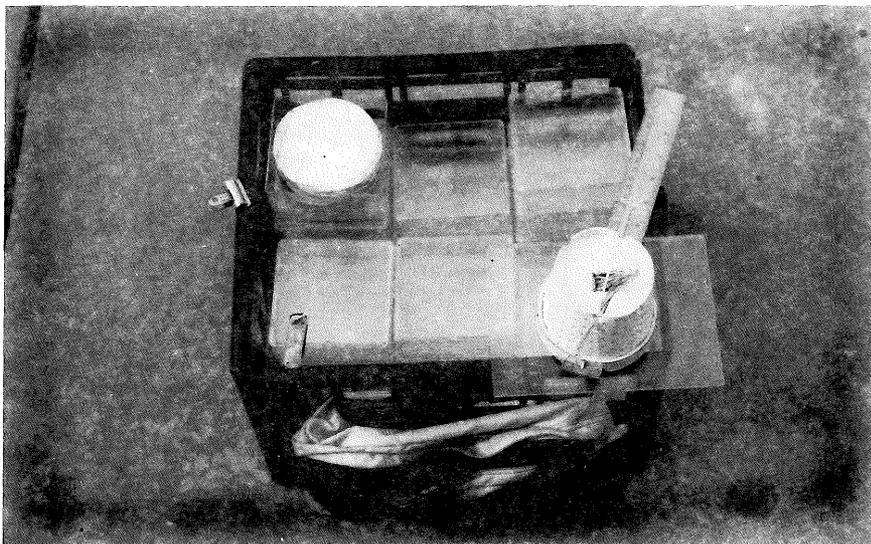


Fig. 2. Carrier used to take samples in the field. The sampling device is positioned on the plexiglass rectangle with a branch sample inserted.

carrier to provide easy access to pruning shears to cut the branch sample. The 26 samples were obtained in approximately 45 minutes. Samples were examined in the laboratory using a dissecting microscope. Sampling was conducted weekly, as often as possible, from March to October. Five locations in Greene and Christian counties were used in 1992 and three in 1993.

Results and Discussion

All stages of aphids were dislodged with the device. Adults and immatures were more easily removed than eggs. Despite this, not all adults and immatures were trapped on the disc. Some adults and immatures became wedged between needles or were damaged in the sampling process, causing them to adhere to the needles. Nevertheless, population trends for aphids were detected. In 1992 (Fig. 3), aphids were scarce until the latter part of the summer. In the fall of 1992, the populations attained their peak level. Adults and immatures were still found in the early winter. In 1993 (Fig. 4), the pattern was exactly the opposite. Aphids were present early in the spring but completely disappeared by summer.

In 1992, aphids did not cause the death, decline or loss of vigor of the trees. The aphids were a nuisance problem. Live aphids were present on the trees during December. As a result, customers took aphids that were sedentary into their houses. Once indoors and subjected to the warmer temperatures, the aphids

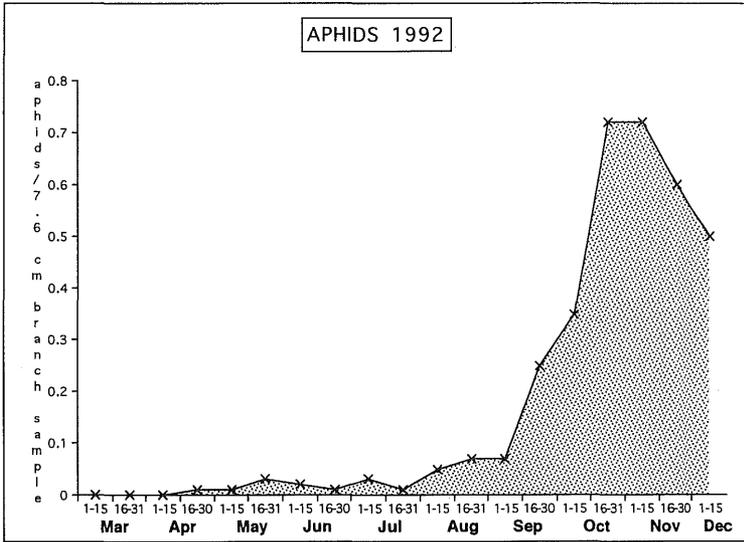


Fig. 3. Aphid populations recorded at five locations in southwest Missouri, 1992.

quickly resumed their activities. Soon, growers were receiving complaints from their customers about “bugs” on the carpets, on the finely-wrapped presents under the tree and at windows. Several customers complained that they feared these bugs

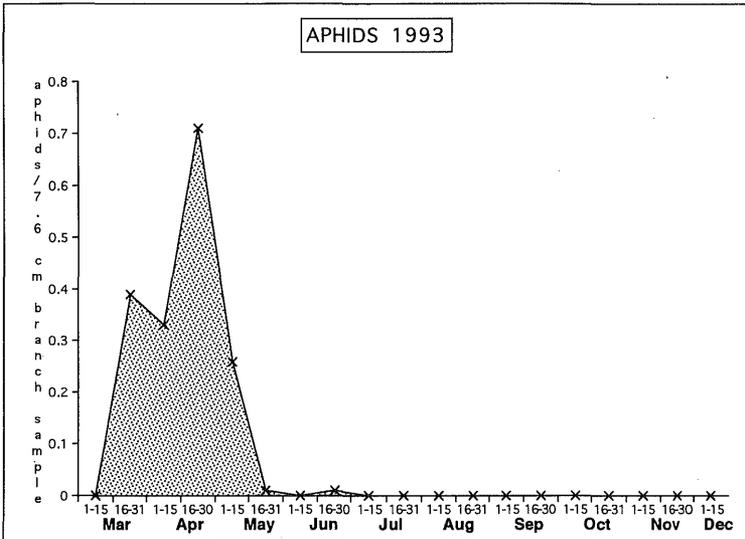


Fig. 4. Aphid populations recorded at three locations in southwest Missouri, 1993.

were going to infest their house plants. While a healthy tree was sold to the customer, the presence of these insects in the home during the holiday season damaged the reputation of growers. Appropriate monitoring of the planting could forewarn growers and allow them to remedy the situation prior to selling the product.

The sampling device is inexpensive and simple to construct from locally available materials. However, it does have limitations. It performs poorly when the foliage is wet. Immediately after a rain or early in the morning, if a heavy dew has formed on plants, sampling should not be conducted. It is necessary to wait until the foliage has dried on these occasions. Moisture off the wet foliage will collect on the sampling device's interior and the smaller invertebrates will adhere to the moist surface. Thus, they are not collected on the petroleum jelly disc. Second, not all invertebrates are removed using this device because the arrangement and number of needles provide too many obstacles. However, by standardizing the number of impacts, raps, from one location to another and from one sampling period to another, patterns of activity are revealed. Finally, after several samplings, the lip of the pint cup begins to curl from the impact of the sampling device on the plexiglass. Therefore, the cup needs to be replaced periodically.

Acknowledgements

I would like to thank the growers who allowed me to use their properties as study areas, the Missouri Department of Conservation for financial support and Dr. Anson Elliott, Department of Agriculture at Southwest Missouri State University, for his support.

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PRELIMINARY MOLECULAR EVOLUTIONARY CHARACTERIZATION OF *Pgr-1*, A METHYLATED PUTATIVE RETROTRANSPOSON SEQUENCE FROM *Pennisetum glaucum* (POACEAE)

(Received, March, 1996; accepted for publication July, 1996)

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Abstract: A putative long terminal repeat (LTR) retrotransposon sequence, *Pgr-1*, from *Pennisetum glaucum* [L.] R. Br. is the first such element described for pearl millet. The 648 bp consensus sequence had several features consistent with its being a 5' LTR region from a retrotransposon. *Pgr-1* shared 66% sequence identity with *Prem-1e*, a putative maize retroelement LTR region; and, *Pgr-1* had the best FASTA alignment with the *Prem-1* maize retroelement family. Phylogenetic analyses of the *Prem-1/Pgr-1* group of retroelements in select grasses suggested this retroelement group arose at least 25-30 million years ago. *Pgr-1* sequences were present in multiple copies in the *P. glaucum* genome, existing as a family of related elements which were not distributed in a tandem arrangement (i.e., they did not show a "ladder pattern" of hybridization on Southern blots). *P. glaucum* genomic DNA digestion with methyl-sensitive/insensitive restriction enzyme isoschizimers, followed by *Pgr-1* hybridization, revealed a high degree of *Pgr-1* methylation, particularly at two highly conserved *EcoRII* sites within or near the consensus sequence shown. *Pgr-1*-like sequences were detectable in a closely related species, *P. purpureum*, but with much less hybridization intensity, suggesting less sequence homology. It is proposed that possible concerted evolution or other *Pgr-1* "homogenization" processes have been at work within as opposed to between these two related *Pennisetum* species. Southern hybridization results were consistent with *Pgr-1* banding pattern differences between *P. glaucum* individuals, suggesting possible recent retrotransposition of family members and accompanied insertional polymorphism, or, the demethylation of specific restriction sites within a subset of *Pgr-1* elements.

Key Words: *Pennisetum glaucum*, *Pgr-1*, putative retrotransposon LTR, methylation, *PREM-1* alignment, molecular evolution, grasses, Poaceae.

Introduction

Retroelements are transposons that replicate via an RNA intermediate (Varmus and Brown 1989). These include vertebrate retroviruses and long terminal repeat (LTR)-retrotransposons found in animals, microorganisms, fungi and plants (Bingham and Zachar 1989; Flavell 1992; Grandbastien 1992; Grandbastien et al. 1994). LTR-retrotransposons are ubiquitous components of higher plant genomes (Flavell et al. 1992a; Voytas et al. 1992) that have extremely diverse amino acid sequences (Flavell et al. 1992b; Flavell 1992). Although select retrotransposons from a number of plant taxa have been well-characterized (Johns et al. 1985; Varagona et al. 1992; Grandbastien et al. 1989; Hirochika and Fukuchi 1992; see additional references in Grandbastien 1992 and in Grandbastien et al.

1994), there are but few studies on the molecular evolution/DNA sequence evolution of particular plant retroelement families (White et al. 1994; Purugganan and Wessler 1994; Casacuberta et al. 1995). Two main groups of "LTR-containing retrotransposons" have been identified, on the basis of gene order and structural features. These are the *Ty1-copia* and *Ty3-gypsy* groups (Flavell 1992). Only a few members of the *Ty1-copia* group have been completely sequenced from higher plants (see Grandbastien 1992 and Grandbastien et al. 1994) and more specifically, few have been completely sequenced from monocot species (Harberd et al. 1987; Moore et al. 1991; White et al. 1994; Murphy et al. 1992; Manninen and Schulman 1993). Even fewer of the *Ty3-gypsy* retrotransposon group have been found so far in plants (i.e., in *Lilium*, *Pinus*, *Lycopersicon* and *Zea*); only two of these are from monocots (Purugganan and Wessler 1994; Smyth et al. 1989).

For better understanding of plant retrotransposon evolution at the structural and DNA sequence levels, to examine retroelement insertion site preferences, and to learn about "host-transposable element" interactions (Sandmeyer et al. 1990), additional families of retroelements must be characterized. This is particularly important in reference to non-maize monocots, where such data are lacking. In addition, characterization of transposable elements from several different grasses, including maize, sorghum, pearl millet, wheat, barley, oats, rice, and others, will aid in mapping of grass genomes, will help elucidate the genetic organization of these important crop plants, and will lead to development of the grass family, Poaceae, as an integrated genetic system in plant biology (Bennetzen and Freeling 1993). Studies of several grass species will complement one another, each adding unique pieces of information that can be applied widely in analyses of all grasses (MacRae and Clegg, 1992; Shimamoto, 1995).

Towards these ends, part of a putative LTR region from a novel retrotransposon family in the grass monocot, pearl millet (*Pennisetum glaucum* [L.] R. Br.) has been PCR-amplified, cloned, and sequenced. This is the first such putative LTR-retrotransposon sequence described from *P. glaucum*, and it is called *Pgr-1*. Also examined were *Pgr-1* presence in a closely related *Pennisetum* species (*P. purpureum* (Schum)), and the *Pgr-1* sequence alignment with a retroelement LTR, *Prem-1*, from maize. These are the first DNA sequence data on the *Pgr-1/Prem-1* group of retroelements outside of the genus *Zea*, and outside of the grass tribe Andropogoneae. In addition, data are presented on the methylation status of *Pgr-1*-like elements in *P. glaucum*; a phylogenetic localization of the *Pgr-1/Prem-1* retrotransposon group in select grasses is shown. Evidence consistent with insertional polymorphism and recent retrotransposition within the *Pgr-1*-like family, or, with the demethylation of specific restriction sites within a subset of *Pgr-1* elements, is given.

Materials and methods

PCR amplification and cloning of LTR

Genomic DNA from *Pennisetum glaucum* variety Tifton 23 DBE (1988 Mead isolate, plant 4) was extracted via Cone's (personal communication) rapid DNA method, as follows. Leaf material (~0.3g) was ground into a fine powder in liquid nitrogen, then 0.6 ml of 1X buffer was added and the slurry was warmed at 42°C followed by shaking at 37°C for 10 minutes. The 1X buffer had 0.35 M NaCl, 0.001 M Tris-HCl (pH 7.6), 0.001 M EDTA (ingredients from a 10X stock), and additional ingredients of 7 M urea, 2% sarkosyl, and 0.05 M EDTA (pH 8.0). Plant material was phenol-extracted with 0.5 ml phenol:chloroform:isoamyl alcohol (100:100:1); this involved gentle vortexing (30 sec.), shaking at 37°C (10 min.), followed by microcentrifugation (5 min.) and removal of the aqueous phase. Nucleic acids were precipitated with 3M NaAc and isopropanol, followed by microcentrifugation (1 min.). The pellet was washed with 70% EtOH, dried, and resuspended in H₂O. PCR amplifications used two 26 base primers: 5' CAACCACAAGAATTAACGGGCAATGG 3' and 5' TAGCGTGAGCACATGCCGTACTCAGC 3', designed from previous *Pgr-1* sequencing (unpublished). PCR mixtures were heated to 93°C for 5 min. before addition of AmpliTaq^R, after which they underwent 35 cycles of: 94°C for 1 min., 75.8°C for 2 min., 72°C for 3 min., followed by a final cycle of 72°C for 15 min., and ending at 4°C. Aerosol-resistant tips were used during all PCR steps. Two separate PCR reactions were done as above; each yielded a single band of ~650 bp, and these were cloned into the General Contractor^R vector (5 Prime-3 Prime company). The *Pgr-1* sequence from which the two 26-mer PCR primers (above) were designed, was originally identified while searching for a separate transposable element (*Spm*), using low stringency PCR amplification (37°C annealing) of pearl millet genomic DNA with 13-base primers.

DNA sequencing and alignments

DNA sequences were obtained using M13 forward and reverse primers as well as internal primers designed from the element. All sequencing was done on individual plasmid clones. To control for PCR errors, four separate clones were sequenced, three from one PCR reaction and one from a separate PCR reaction. Sequencing of three clones was done using the dideoxy method (Sanger et al. 1977) and the Sequenase^R Kit (United States Biochemical Co.). Sequencing of the fourth clone was done using the Amplicycle^R Kit (Perkin Elmer) under the following conditions: 95°C for 2 min., 95°C for 45 sec., 60°C for 45 sec., 72°C for 1 min. Sequences of all four clones were determined on at least one strand, with

multiple regions of double-stranded overlap. All clones were then simultaneously manually aligned.

The consensus sequence was identified as follows (see Fig. 1): where 3/4 or 4/4 of the clones had the same base at a given position (i.e., at the majority of base positions), that base was assigned to the consensus. If two clones had one base and the other two clones both had another base at a given position, both bases were indicated in the consensus. In the rare case of two clones having one base and the other two clones having two different bases, the base sequence of the two identical clones was assigned to the consensus at that position. Of 648 bases, only

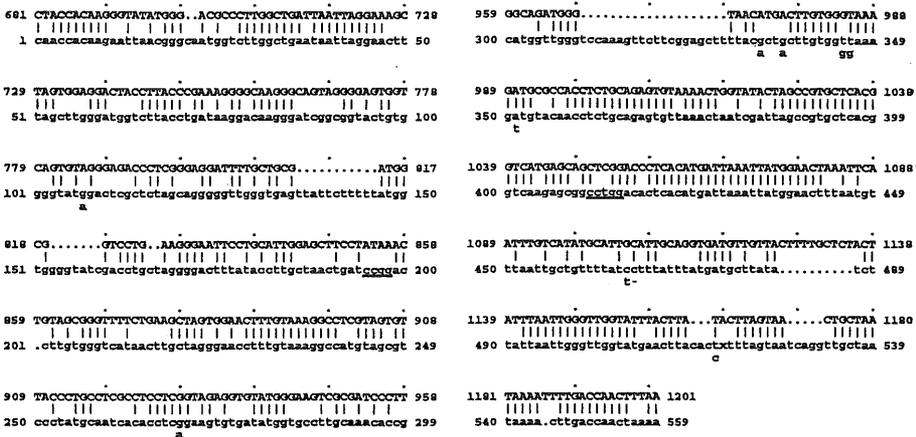


Fig. 1. BESTFIT alignment of *Prem-1e* maize retrotransposon 5' LTR region (top line; upper case) with *Pgr-1* pearl millet putative retrotransposon LTR region (bottom line; lower case). Vertical lines indicate identical bases. Dots on either sequence line indicate gaps in one sequence relative to the other. Dots above the alignment mark increments of ten bases. The *Pgr-1* sequence shown is a consensus. The *Bst*NI restriction site and the *Msp*I restriction site are underlined. For ambiguous *Pgr-1* bases (see Methods), the possible alternative base is shown underneath. The single "dash" below a C (*Pgr-1* base 467) indicates an alternative of no base (a gap) at that position. The "X" (*Pgr-1* base 519) indicates an unspecified base at that position. A representative *Pgr-1* clone sequence is in the GenBank database (No. U32150). Additional *Pgr-1* sequences are available upon request.

11 bases could not be assigned unambiguously to the consensus sequence, due to two clones having one base (e.g. A) and two clones having a second base (e.g., G) at that position, or no base (i.e., a gap) at that position (see Fig. 1 and legend).

Sequence identification and alignment was done using the Genetics Computer Group (GCG) programs FASTA and BESTFIT (Devereux et al. 1984). Maize-pearl millet retroelement genetic distance was calculated via Kimura's 3-parameter method (Kimura 1981), using only sites where all four sequenced pearl millet clones were identical, or, sites where a consensus base existed among the four clones.

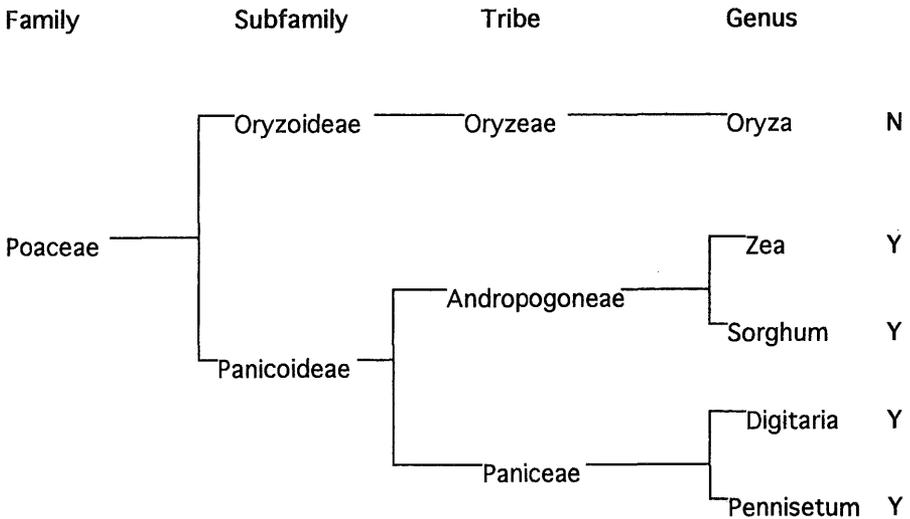


Fig. 2. Phylogeny of select grasses (Poaceae) showing presence/absence of sequences related to *Prem-1* or *Pgr-1*. Selected grass subfamilies, tribes and genera are shown, together with indication of presence (Y) or absence (N) of detectable *Prem-1/Pgr-1*-related sequences. Genera for which sequence data exist are *Pennisetum* (this paper) and *Zea* (Turcich and Mascarenhas 1994); *Sorghum* and *Digitaria* data are from Southern blot analyses (Turcich and Mascarenhas 1994). Phylogenetic relationships shown are not meant to indicate branch lengths or accurate times of divergence.

Southern blots

Ten micrograms of *P. glaucum* and *P. purpureum* genomic DNAs were digested with either *Msp*I, *Hpa*II, *Eco*RII or *Bst*NI (Figure 3) following manufacturer's specifications and the digests were fractionated on a 0.8% agarose gel. The DNA fragments were transferred to nitrocellulose by standard procedures, baked 2 hrs. at 80°C under vacuum, then hybridized at 50°C for 3 days. Hybridization was with a ³²P-labeled *P. glaucum Pgr-1* probe that had been purified after separation by electrophoresis on an agarose gel. For Fig. 3, a 720 bp *Pgr-1* probe obtained by PCR and subsequent cloning (as described above), was used; it shared 94% identity to the consensus *Pgr-1* sequence (Fig. 1), across 433 bp. Hybridization, washing and film exposure conditions were as described in Rogstat et al. (1988).

In some experiments (Fig. 4) genomic DNAs from different varieties of *P. glaucum* were digested with *Hind*III, and, after fractionation on a 0.7% agarose gel, were transferred to Zeta Probe GT nylon membrane (Ausubel et al. 1992). The following three *P. glaucum* varieties were used: Tifton 23 DBE (an early

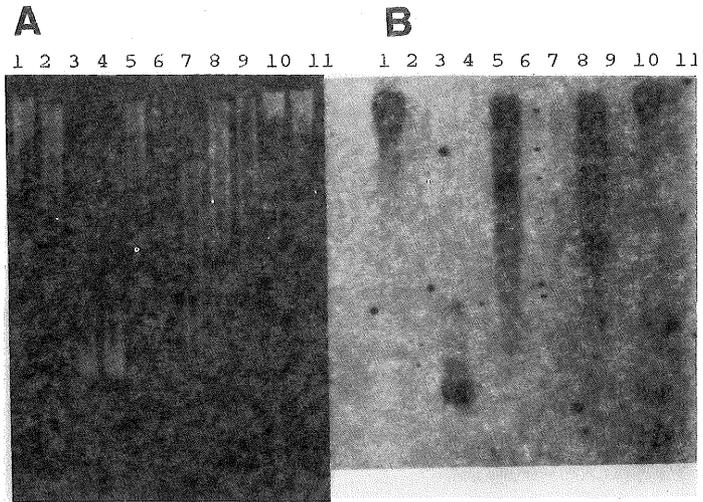


Fig. 3. Methylation of *Pgr-1*-related sequences. Genomic DNAs are from *P. glaucum* (lanes 1, 3, 5, 8, and 10, darkly hybridizing in panel **B**) or *P. purpureum* (lanes 2, 4, 7, 9, and 11, lightly hybridizing in panel **B**). DNAs were digested with methyl-sensitive/insensitive enzymes *EcoRII* (lanes 1 and 2), *BstNI* (lanes 3 and 4), *MspI* (lanes 5 and 7), *HpaII* (lanes 10 and 11), or *HpaII* and *MspI* together (lanes 8 and 9), fractionated on a 0.8% agarose gel and Southern-transferred to nitrocellulose. The membrane was hybridized with a *Pgr-1* probe (panel **B**). Panel **A**: Ethidium bromide-stained gel prior to Southern transfer. Lane 6 in **A** and **B** is the lambda-*HindIII* molecular marker, with fragment sizes (in kb): 23.1, 9.4, 6.6, 4.4, 2.3, 2.0.

inbred line originally from Tifton, GA), Tifton 23A x 57028 (a single cross hybrid made from two inbred parents), and N-MLS (a heterogeneous early dwarf variety derived from a random mating population made with African, Indian and U.S. germplasm sources). The fragments were UV-linked to the nylon support by standard conditions, then hybridized at 65°C for 2 days with a ³²P-labeled *P. glaucum Pgr-1* probe. For Fig. 4, a 684 bp *Pgr-1* probe obtained by PCR and subsequent cloning (as described above) was used; it shared 90% identity to the consensus *Pgr-1* sequence (Fig. 1), across 646 bp. Hybridization, washing and film exposure were as described by Ausubel et al. (1992). All ³²P-labeled probes used for southern hybridizations had specific activities of at least 10⁸ cpm per microgram and were greater than 90% similar to the consensus sequence (Fig. 1)

Results

Pgr-1 from *Pennisetum glaucum*: sequence analysis and alignment with *Prem-1*

The consensus sequence of *Pgr-1*, part of a putative retrotransposon LTR, is presented in Fig. 1. Also presented in Fig. 1 are the *BstNI* and *HpaII* restriction sites contained within the *Pgr-1* sequence, and the *Pgr-1* alignment with the *Prem-1* maize retroelement LTR. A FASTA computer search of the plant database

showed *Pgr-1* from *P. glaucum* had the best alignment with the LTR region from several members of a maize putative retroelement family, *Prem-1*. This

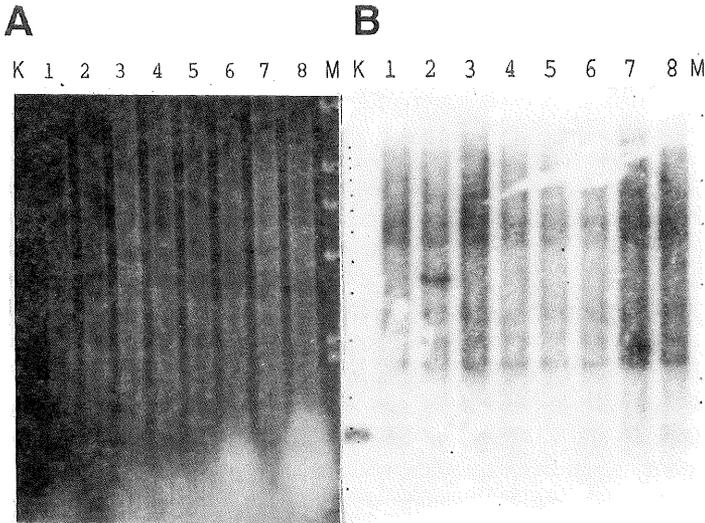


Fig. 4. *Pgr-1* banding differences between *P. glaucum* individuals. Genomic DNA from three *P. glaucum* varieties was digested with *Hind*III, fractionated on a 0.7% agarose gel and Southern-transferred to nylon membrane. The membrane was hybridized with a *Pgr-1* probe (panel **B**). Panel **A**: Ethidium bromide-stained gel prior to Southern transfer. Lanes 1-4 are individual plants of the N-MLS variety; lanes 5-7 are individual plants of the Tifton 23 DBE variety; lane 8 is of the "Tifton 23A x 57028" hybrid variety. Lane "M" in **A** and **B** is the lambda-*Hind*III marker whose fragment sizes (in kb) are: 23.1, 9.4, 6.6, 4.4, 2.3, 2.0 and 0.56. Lane "K" in **A** and **B** is the kilobase ladder with fragment sizes (in kb): 12.2, 11.2, 10.2, 9.2, 8.1, 7.1, 6.1, 5.1, 4.1, 3.1, 2.0, 1.6, 1.0.

retroelement is preferentially transcribed in maize pollen (Turcich and Mascarenhas 1994). From a BESTFIT alignment (Fig. 1), overall 66% of the bases were identical between the two sequences, with alignment extending from base 681 to base 1201 of *Prem-1e* and base 1 to base 559 of *Pgr-1*. Ten gaps in the sequence alignment were included (Fig. 1); most of these (7/10) resulted from insertions in *Pgr-1* compared to the *Prem-1e* sequence. Kimura's evolutionary distance was estimated to be 0.46 ± 0.04 nucleotide substitutions per site, for the sequences aligned in Fig. 1.

Phylogenetic localization of the *Prem-1/Pgr-1* group in select grasses

A phylogenetic analysis of the joint distribution of *Prem-1* and *Pgr-1*-related sequences in select grasses (Poaceae) is presented in Fig. 2. From both current and previous DNA sequence data and from previous Southern blot hybridization data (Turcich and Mascarenhas 1994), it was determined that *Prem-1/Pgr-1*

sequences are present in the grass subfamily Panicoideae, specifically in these four genera: *Zea*, *Sorghum*, *Digitaria* and *Pennisetum*. However, previous Southern blot hybridizations failed to detect *Prem-1/Pgr-1*-related sequences in the more distant grass subfamily Oryzoideae, as evidenced by examination of the grass genus *Oryza* (Turcich and Mascarenhas 1994) (Fig. 2)

Genome methylation and specific methylation of the *Pgr-1* sequence plus surrounding sequence context

Genome methylation, methylation of *Pgr-1* sequences, and methylation of their surrounding sequences were investigated in *P. glaucum* and *P. purpureum*, using methylation-sensitive and insensitive isoschizimer enzyme pairs (*EcoRII* and *BstNI*; *HpaII* and *MspI*). There was a high degree of genome methylation at 5' CCGG 3' (*HpaII/MspI* recognition site) and at 5' CCA/TGG 3' (*EcoRII/BstNI* recognition site) for both *P. glaucum* and *P. purpureum* (Fig. 3A). However, the *P. glaucum* genome as a whole was more highly methylated at both these sites than was the *P. purpureum* genome, as seen from *EcoRII* (lanes 1 and 2; Fig. 3A) and *HpaII* (lanes 10 and 11; Fig. 3A) digestion comparisons between the two species. Approximately equal DNA amounts were loaded in all lanes.

Studies on the methylation of *Pgr-1* and surrounding sequences in *P. glaucum* and *P. purpureum* yielded 3 results (Fig. 3B): 1) similar hybridization patterns in *P. purpureum* and *P. glaucum*, although signal intensity was much less in *P. purpureum*; 2) *P. glaucum* *Pgr-1*-related sequences or their surrounding sequences were highly methylated at 5' CCGG 3' and 5' CCA/TGG 3' sites, as seen by comparison of *EcoRII* (lane 1; Fig. 3B) and *BstNI* (lane 3; Fig. 3B) hybridizing lanes, and by comparison of *HpaII* (lane 10; Fig. 3B) and *MspI* (lane 5; Fig. 3B) hybridizing lanes. There is a single *EcoRII/BstNI* site within the *Pgr-1* sequence (Fig. 1), and also a single *HpaII/MspI* site within the *Pgr-1* sequence (Fig. 1). The *P. glaucum* *MspI* hybridizing lane (lane 5) showed that *Pgr-1*-related sequences (family members) were present on numerous genomic *MspI* fragments of size-range > 23 kb to < 2.0 kb; 3) *P. glaucum* *BstNI* hybridization (lane 3) showed a highly conserved *BstNI* band of ~400 bp, as well as about two to three lighter hybridizing bands of higher molecular weight. Thus, lane 3, Fig. 3B shows that there are additional *BstNI* sites, conserved in most of the *Pgr-1*-related elements.

Hybridization of *Pgr-1* across individuals from three *P. glaucum* varieties

A Southern blot of *HindIII*-digested *P. glaucum* genomic DNAs was hybridized to a *Pgr-1*-related probe (Fig. 4). The results from genomic DNAs isolated from multiple individual plants of three *P. glaucum* varieties are shown. Equal amounts of genomic DNA were loaded in all lanes (Fig. 4A). Hybridization patterns across all three varieties were similar and indicated a non-tandem arrangement of *Pgr-1* sequences (i.e., a non-"ladder pattern" of hybridization). This type of analysis has the potential to determine if *Pgr-1*-like sequences reside in

the same genomic location(s) across pearl millet varieties. One individual plant (lane 2, variety N-MLS) showed a striking difference from the others, namely a ~4.5 kb strongly-hybridizing band that appeared absent in all other lanes (Fig. 4B). These digestions and Southern blot were repeated multiple times, all with the same result, thus strongly suggesting the results were not due to incomplete digestion of DNA from plant number 2 of the N-MLS variety.

Discussion

The *Pgr-1* sequence suggests it is part of a putative retroelement LTR, since it aligns well with a maize *Prem-1* retroelement LTR. *Pgr-1* has the following additional features: **1)** sequences similar to a 5' LTR promoter CCAAT box (bases 311-315); **2)** sequences similar to a 5' LTR promoter TATA box (bases 470-476); **3)** potential priming sequences complementary to the 3' most end of tRNA^{Met}, found in all plant retroelements (bases 502-507) (Grandbastien 1992). Although most plant retroelements characterized share a 10-20 nucleotide region of complementarity to the tRNA^{Met}, and thus to one another, the extent of similarity within this region varies between retroelements. For example, the maize *Magellan* retroelement (Purugganan and Wessler 1994) shares only 7 nucleotides (TGGTATC) of similarity with the maize *Prem-1e* retroelement, at their respective presumed sites of tRNA^{Met} binding (PBS). This is also comparable to the number of nucleotides (six) shared between *Pgr-1* and *Prem-1e* at their respective, presumed sites of tRNA^{Met} binding. The fact that the three *Pgr-1* sequence features described above appear in the correct order within the presumed LTR region (5'--CCAAT box--TATA box--tRNA^{Met}PBS--3'), although not strong evidence, is further support that these regions are, or were, possibly functional components of *Pgr-1* at one time. Further characterization of *Pgr-1* sequences from lambda clones is needed to determine if there are *Pgr-1* elements that have two complete LTRs (LTRs ending in CA and starting with TG), if reverse transcriptase sequences exist, or if reverse transcriptase activity can be provided in trans to *Pgr-1*, as for *Bs-1* (Jin and Bennetzen 1989).

Several open reading frames were found in the 648 bp *Pgr-1* consensus sequence; the longest encoded 44 amino acids. It is noteworthy that sequences similar to a large, internal region of the lily *del* element (*pLh505*, part of a *Ty3/gypsy*-like element; Joseph et al. 1990) were seen in *P. glaucum*, by screening a genomic DNA EMBL3 library (MacRae unpublished results). These data support the idea that *P. glaucum* may contain internal retroelement sequences in addition to putative LTRs.

The consensus *Pgr-1* sequence contains bases where in 4 out of the 4 or in 3 out of the 4 clones, the same base is located at a given position (see Methods). By presenting a consensus, the conservative assumption is made that differences among clones may be the result of misincorporation by *Taq* polymerase (Eickbush

and Eickbush 1995). A more likely alternative to the idea of PCR-generated errors is the existence of natural sequence variation in individual *Pgr-1* elements at those LTR positions. Such sequence variation could be generated via rapid retroelement evolution, produced by processes such as error-prone reverse transcription and the deamination of methylated C residues (Doolittle et al. 1989; Drake 1993; Eickbush et al. 1995). One cannot distinguish these two hypotheses currently, however sequencing of lambda genomic *Pgr-1*-related clones should resolve this issue. Also, reduction in the total number of PCR reaction cycles and use of polymerases that contain proofreading activity will further aid in distinguishing these two hypotheses.

For alignment of the *Pgr-1* sequence with the *Prem-1* sequence from maize, a particular *Prem-1* clone was selected (*Prem-1e*). Of the six genomic *Prem-1* clones (clones #1 and #1a-1e, obtained via maize 'W-22' EMBL3 library screening; Turcich and Mascarenhas 1994; Hamilton et al. 1989), each clone is between 2%-11% divergent from the other clones, in the region of best alignment with *Pgr-1* (over *Prem-1* bases ~700-1700). Thus, a similar percent DNA identity would be predicted if the *Pgr-1* sequence were aligned with any of the other five *Prem-1* maize clones.

The BESTFIT alignment of the 648 bp *Pgr-1* consensus sequence with the *Prem-1e* LTR sequence only extends to base 559 of *Pgr-1*. The fact that there are 89 additional, sequenced bases in the *Pgr-1* consensus that appear not to align well with the *Prem-1e* LTR, can be explained by three hypotheses: 1) These additional, sequenced *Pgr-1* bases could represent part of or all of a small insertion in *Pgr-1*, similar to the other, seven insertions shown in *Pgr-1* relative to *Prem-1e*; 2) The additional *Pgr-1* bases with no similarity to *Prem-1e* could indicate that *Pgr-1* elements exist in *P. glaucum* in different forms: as parts of an LTR only, plus as potentially complete retroelements; 3) The additional *Pgr-1* bases could be evidence of an interruption within a retroelement, similar to the maize *Bs-1* retroelement, interrupted by a fragment of the plasma membrane proton ATPase gene (Jin and Bennetzen 1994). Characterization of full-length *Pgr-1* lambda clones (underway) is necessary to distinguish these three hypotheses, and to thus determine what comprises the remainder of the *Pgr-1* sequence. The evidence that *Pgr-1* corresponds to the LTR of a retrotransposon will be considerably augmented by such characterizations of full length lambda clones.

Kimura's evolutionary distance estimated between *Prem-1e* and *Pgr-1* sequences is comparable to (actually slightly higher than) the average number of synonymous substitutions for coding regions of the *Adh1* gene between maize and pearl millet (MacRae et al. 1994; Gaut and Clegg 1991). Assuming *Pgr-1* and *Adh1* divergence times are equivalent between maize and pearl millet, this is consistent with the hypothesis that this region, as a block, has not been strongly constrained by natural selection during its long-term evolution (MacRae et al. 1994; MacRae and Clegg 1992). The 10 gaps in the *Pgr-1/Prem-1e* BESTFIT alignment, most of these insertions in *Pgr-1* relative to *Prem-1e*, are consistent with crossing-over or ectopic exchange having occurred within *Pgr-1* family members (Langley et

al. 1988). This type of exchange also can permit homogenization of retroelement members within a species (Kamm et al. 1994; Willard and Wayne 1987). The detection of one major *Bst*NI band on genomic Southern blots argues for such *Pgr-1* sequence homogenization, since this ~400 bp putative LTR region appears highly conserved within *P. glaucum*.

Phylogenetic analyses can suggest when a given transposon or repeated sequence family arose, and indicate whether horizontal transmission has played a role in its distribution (Flavell 1992; Eickbush and Eickbush 1995; Doolittle et al. 1989). A phylogeny of select grasses is given, adapted from Davis and Soreng (1993) and Turcich and Mascarenhas (1994). Genera in which members of the *Prem-1/Pgr-1* group are found, are indicated. The genus in which *Prem-1* is presumed absent, is indicated. In their analysis of *Prem-1* distribution, Turcich and Mascarenhas (1994) noted that under high stringency, no *Prem-1*-related sequences were detected outside the genus *Zea*. However, under low stringency hybridization conditions (55°C), Turcich and Mascarenhas (1994) also found *Prem-1*-related sequences (via Southern blots) in *Sorghum* and to a lesser extent in *Digitaria*, but not in *Oryza*.

The finding of *Pgr-1* (sequences related to *Prem-1*) in *P. glaucum* and to a lesser extent in *P. purpureum*, is consistent with the observations of Turcich and Mascarenhas (1994). If *Prem-1* and *Pgr-1* sequences are seen as part of a larger group of related sequences (the *Prem/Pgr* group) then the following conclusions can be drawn. *Prem-1* sequences are not present in rice, suggesting they originated after maize and rice lineages diverged ~50 mya (Turcich and Mascarenhas 1994; Bennetzen and Freeling 1993). Members of the *Prem/Pgr* group had been found previously in *Zea* and *Sorghum*, two lineages thought to have diverged ~20 mya (Turcich and Mascarenhas 1994; Bennetzen and Freeling 1993). The current data suggest members of the *Prem/Pgr* group also exist in *Pennisetum*, with the *Zea* and *Pennisetum* lineages diverging ~25-30 mya (Huttley et al. 1995).

A phylogenetic distribution of the *Prem/Pgr* group suggests these sequences have been subject to vertical transmission during their evolution within the Panicoideae. A more extensive study may, however, reveal instances of putative horizontal transmission. For example, Turcich and Mascarenhas' (1994) detection of a possible *Prem-1* sequence in wheat (*Triticum*) but not in rice (*Oryza*), may hint at a horizontal transfer event. An alternative explanation for *Prem-1* presence in Panicoideae and also in the separate Pooideae clade, but not in *Oryza*, however, may be loss of *Prem-1* in *Oryza*. This scenario is supported by a strict consensus tree of grasses (Davis and Soreng 1993), which positions Oryzoideae as more evolutionarily derived than the Panicoideae/ Arundinoideae/ Centothecoideae/ Chloridoideae clade. There is in fact conflicting evidence as to whether Oryzoideae is cladistically basal to Panicoideae. Davis and Soreng (1993) and Soreng and Davis (1995) support a basal position of Oryzoideae, and this agrees with *Prem/Pgr* sequences having originated after maize and rice diverged.

However, Clark et al. (1995) and Duvall and Morton (1995) give evidence not necessarily supporting a basal Oryzoideae, thus calling into question the maize/rice lineage divergence time of ~50 mya. Since there is uncertainty about timing of the maize/rice lineage divergence, it may not be possible to use the absence of *Prem-1* in *Oryza* as a dating event for when *Prem/Pgr* sequences arose. A more extensive sampling of *Prem/Pgr* sequences within other grass lineages (underway) is needed to resolve when such sequences arose. At this time, it can be stated that the *Prem/Pgr* group originated at least ~25-30 mya (Huttley et al. 1995), the time when *Zea* and *Pennisetum* lineages are thought to have diverged.

The methylation status of repeated sequences, including transposons, can vary between element families and can be associated with functions such as transcription and transposition. For example, methylation status in *Activator*, *Suppressor-mutator*, *Mutator* and *Tam* element families is associated with their transposition function (Chomet et al. 1987; Fedoroff 1989; Bennetzen 1987; Martin et al. 1989). However, other highly repeated plant sequences such as tandemly arranged satellites and certain telomere-associated sequences are highly unmethylated (Kamm et al. 1994; MacRae 1994; MacRae unpublished results); thus methylation may not be associated with function in these sequences.

Methylation and associated transcription-competence or transposition-competence has not been well-studied for plant retroelements or other repeated sequences. In fact, "very little is known about the expression of plant retrotransposons and retroposons" (Grandbastien 1992) and few retroelements are thought to be expressed under normal (non-stress) conditions (Wessler et al. 1995). Results presented here suggest that one *HpaII* restriction site and one *BstNI* restriction site (i.e., one end point of the strongly-hybridizing ~400 bp *BstNI* fragment) are contained within the *Pgr-1* consensus sequence. The other end point of the ~400 bp *BstNI* fragment is presumed to lie just outside the *Pgr-1* region presented here. The existence of one, primary *BstNI* hybridizing fragment means this fragment is conserved across almost all members of the *Pgr-1* family in *P. glaucum*; it also means that both the two "*BstNI/EcoRII*" sites within or near this consensus sequenced region are methylated in most all *P. glaucum Pgr-1* family members (*P. glaucum EcoRII* vs. *P. glaucum BstNI* hybridization). The finding of a high degree of methylation for *Pgr-1*-related sequences, particularly at highly conserved *EcoRII* sites within or near the *Pgr-1* consensus sequence is interesting, because it may suggest a means of *Pgr-1* regulation via methylation and demethylation. Since methylation is reversible (a form of epigenetic regulation), and since it often is inversely associated with transposable element and gene transcription (Schlappi et al. 1994), it would be interesting to investigate levels of *Pgr-1* transcription in relation to *Pgr-1* methylation (preliminary results indicate *Pgr-1*-related transcripts exist in leaves from pearl millet).

Overall genome methylation results presented here also are consistent with those of Kumar et al. (1990), who found variation in methylation amounts within six millet DNAs. The fact that the *P. glaucum* genome is more highly methylated than that of *P. purpureum* at specific sites opens the way for investigations of

whether retrotransposon and other repeated sequence methylation levels strictly follow genome methylation levels (Moore et al. 1993), or if the two can be uncoupled.

There are multiple, *Pgr-1*-related sequence copies in *P. glaucum* at varying genomic locations (i.e., they do not show a regular "ladder pattern", as would be evidenced by tandemly arrayed sequences). Some sequences potentially have greater similarity to the *Pgr-1* probe than do others, and there is a possibility that certain genomic regions may contain higher copy numbers of *Pgr-1*-related sequences, and/or have multiple copies of *Pgr-1*-like sequences that are more highly related to one another. These interpretations are subject to further tests via DNA sequencing of lambda clones and via *in situ* hybridization studies. Since typical plant retroelements range in size from ~0.4 kb- ~9.3 kb, with a mean size of ~5.7 kb (Grandbastien 1992), this suggests that the many, *Pgr-1*-hybridizing bands of varying sizes are a family of related sequences, which are not tandemly distributed in the *P. glaucum* genome. Similar non-tandem distribution patterns are observed for the *mys* retrotransposon (Baker and Wichman 1990), and for the distribution of several retrotransposons and retroviruses (Sandmeyer et al. 1990; Kirchner et al. 1995).

P. purpureum has sequences that weakly hybridize to *Pgr*-like sequences. This indicates the presence in *P. purpureum* of sequences with only limited similarity to the *P. glaucum Pgr-1* sequence. Plant repeated sequences can be family, genus or species-specific (Ingham et al. 1993; Kamm et al. 1994) and plant retroelements, although ubiquitous, may vary considerably in sequence (Flavell et al. 1992a,b; White et al. 1994). Reverse transcription processes associated with retrotransposition can contribute to high retroelement diversity, as can the deamination of methylated C residues (Voytas et al. 1992; Purugganan and Wessler 1994). It also is possible that processes of concerted evolution (Zimmer et al. 1980) may cause retroelements and other repeated sequences to become "homogenized" within a species (*P. glaucum*) yet become quite divergent between closely related species (*P. glaucum* and *P. purpureum*). The high divergence in *Pgr-1*-related sequences between *P. glaucum* and *P. purpureum* is consistent with such "concerted evolution" processes.

It also is interesting that *Pgr-1*-related sequences are somewhat conserved at the DNA sequence level between maize and pearl millet, yet are quite divergent within the *Pennisetum* genus. *P. glaucum* has a single nuclear genome (A genome), whereas *P. purpureum* is a polyploid (A'B genomes), the later species probably having evolved from an interspecific cross, with *P. glaucum* as one of the progenitors of *P. purpureum* (Ingham et al. 1993). In a phylogenetic sense, *P. purpureum* can be thought to be more "derived" than *P. glaucum*. Thus, it may not be unusual that *Pgr-1* sequences have diverged or been "lost" within the polyploid *P. purpureum* genome. Additional sequences from *Pennisetum* species are required to test actual levels of within-genus *Pgr-1* divergence. Such data could

also test whether different evolutionary forces (selection vs. mutation/drift) or different intensities of forces could act on retroelement sequences at varying taxonomic levels (within a genus vs. within a grass subfamily).

Insertional polymorphism between conspecific plant varieties (also polymorphism between individuals) has been used to document recent retroelement activity (Schwarz-Sommer et al, 1987; Lee et al. 1990; Grandbastien 1992). Number of retroelement copies also can indicate recent element activity via replication and retrotransposition (e.g., only 1-2 copies of *Arabidopsis Ta* element families, thought to be inactive, versus > 13,000 copies for the *Lilium del 1* element family; Grandbastien 1992). The observation of an additional hybridizing band in one plant (N-MLS variety) could be due to gain of a *HindIII* restriction site, however, if this were true one might expect to see similar restriction site differences in other individuals or varieties. It could also be due to select amplification of a specific sequence lying between two *HindIII* sites, or, to specific demethylation of the *HindIII* sites of a subset of *Pgr-1* elements. Further tests with several, additional restriction enzymes are needed, to confirm whether the observed banding difference is due to a *HindIII* restriction site difference, to specific demethylation of selected *HindIII* sites, or possibly to a recent retrotransposition event. Nevertheless, the data are consistent with multiple element copies, and with banding pattern differences in the N-MLS *P. glaucum* variety, potentially due to recent retrotransposition or to demethylation of selected element copies. If *Pgr-1* family members are found to be mobile retroelements, this would add to the limited number of plant retroelements thus far identified as mobile in their respective genomes: *Bs1* (Johns et al. 1989; Jin and Bennetzen 1989; Fuerstenberg and Johns 1990), *Wis-2* (Harberd et al. 1987; Moore et al. 1991), *Tnp2* (Vaucheret et al. 1992), *Tnt1* (Grandbastien et al. 1989; Pouteau et al. 1991) and *Tto1-2* (Hirochika 1993).

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FARMING SYSTEMS RESEARCH LESSONS LEARNED FOR TECHNOLOGY DEVELOPMENT IN SEMI-ARID AREAS

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Abstract: Increasingly, farming systems research (FSR)¹ practitioners are working in semi-arid areas where the environment is "harsh" for crop production. The major environmental constraint is the amount and distribution of precipitation. Other limiting factors include high temperatures, poor soil, and socio-economic problems. Farmers' traditional responses include irrigation, choosing drought tolerant crops, sequential decision making, and buffering with livestock enterprises and off-farm employment. Implications for FSR include an emphasis on breaking constraints. This requires increased farmer participation, developing a range of appropriate technology options, and providing a diverse group of farmers, who have widely varying access to resources, with recommendations containing targeting and conditional information. Yield stability and minimum investment may be more important than maximizing yield. FSR projects must be closely linked to the local situation, but because harsh environments are also often fragile, it is incumbent on FSR teams to take special note of environmental and sustainability issues.

I. Introduction

A great many, perhaps most, of the world's farmers practice their agricultural trade in less than ideal environments. Farmers face many environmental constraints: cold; heat; too little moisture; too much moisture; great variability in moisture between and within seasons; etc. Farmers who face these conditions may be characterized as "farming in a 'harsh' environment". Among the "harsh" environments faced by agriculturalists, the semi-arid savanna environments² of the world provide major challenges to cropping agriculture. While the semi-arid savanna areas have traditionally not supported large segments of the world's population, they are becoming more important as population pressures in many countries are forcing farmers to open marginal lands.

Farming systems research practitioners, as well as experiment station based researchers, face a number of constraints and challenges when developing agricultural technologies for farmers working in semi-arid areas. In this paper we will address some of the challenges of conducting FSR in a harsh environment; we will primarily address those challenges affecting cropping rather than livestock enterprises. We begin by examining a number of the constraints related to cropping

¹FSR is an approach involving farmers in on-farm research aimed at improving their productivity and hence standard of living. Farmers involved in FSR projects generally have limited resources and in some parts of the world are predominantly women, which adds additional constraints.

²These types of environments are most common in Sub-Saharan Africa and also in certain parts of Latin America and Asia.

agriculture in semi-arid areas and the coping strategies farmers have developed in response to harsh environments.³ Some of the implications when using the farming systems research method to address these constraints are then discussed.

II. Environmental Constraints

By definition a semi-arid area has limited precipitation. Semi-arid areas may be considered areas with less than 15 inches (380 mm) of rainfall. Rainfall in savannas varies widely from as high as 1200 mm per year in the humid areas, to as little as 200 mm where the savanna meets the desert (a desert receives 10 inches--255 mm--or less rainfall). As Norman et al. (1984), have pointed out, there are major challenges to developing agriculture in the 400-600 mm rainfall zone in Southern Africa. However, this zone is becoming more and more important as rapidly growing populations enter the zone in greater numbers, seeking land suitable for agriculture. Our observation is that the agricultural challenges found in Southern Africa are similar to challenges faced by farmers in many semi-arid zones worldwide.

Total annual precipitation is only one aspect of farming in semi-arid regions. The "normal" distribution of the moisture over the year is also important. Agriculture in semi-arid temperate areas, where winter snowfall can build up a soil moisture reserve, followed by rains distributed through the spring and summer, is an easier environment for farming than a savanna area which may receive its total annual precipitation in two to four high intensity rainfall events during the heat of the summer.

Crop farmers who face a fairly consistent precipitation pattern are able to adjust their cropping strategy accordingly. In temperate semi-arid zones there is some consistency to the precipitation patterns, even if they are not entirely predictable. In much of the tropical and sub-tropical low-rainfall savanna there is great variation in rainfall between years and within years. For example, in Francistown, Botswana, an annual average of 475 mm (19 inches) of rain was achieved by combining a number of years with rainfall of 250 to 350 mm with one year of 1200 mm.

The variability in rainfall distribution within years increases the risk for farmers. Even if an area receives a fairly constant amount of precipitation from year to year, there may be great variability in when the rains come within the year. Again using the Francistown area as an example, it has a growing season which runs from October through April. An examination of meteorological data indicates that within this approximately 23 week growing season, there is a greater than 90

³While the authors have worked with agriculture in harsh environments worldwide, much of this paper is based on experience gained by the Agricultural Technology Improvement Project over a period of eight years (1982-90) in Botswana, Africa.

percent chance of having one or more dry periods (no rainfall event of 10 mm or more) of four or more weeks, and there is a greater than 50 percent chance of having a dry period of seven or more weeks. In this area planting is typically done on fields with little or no stored soil moisture. Thus, extended dry periods almost inevitably lead to crop failures.

While the major constraint facing farmers in semi-arid areas--particularly low-rainfall savannas--is the small total amount of rainfall available, often coupled with poor distribution, there are other factors that contribute to the harshness of the climate. High ambient temperature is one of these factors. Not only can temperatures at the soil surface become high enough to kill small plants, but the high evapotranspiration resultant from high temperatures means that, as in Botswana, there may be no month during the year when rainfall exceeds evapotranspiration. Other factors include poor soil, localized rains--not generalized over large areas, and rugged terrain. Exacerbating the climatic factors are poorly developed markets and other infrastructure, and a lack of management skills and resources on the part of farmers.

III. Traditional Response to Constraints in a Harsh Environment

There is a great deal of heterogeneity among farming systems operating in semi-arid environments. Over the centuries farmers in these environments have developed a number of strategies to address limited water availability and other constraints. These traditional responses are usually aimed at using the available water more efficiently.

One of the oldest and most effective approaches to improving agriculture in a semi-arid environment is to modify the micro-environment for the plants in the field. With regard to limited water availability, this has usually been done by adding additional water to the micro-environment through irrigation schemes. Irrigation strategies have ranged from major, large-area projects to import water from a distant source, to small-area catchments that concentrate water on a single field. While irrigation is an important method of modifying harsh environments, the lack of available surface water or groundwater, the cost of implementing irrigation schemes, etc. have forced farmers in semi-arid areas to develop other responses.

The choice of type and variety of crop planted is one such response. Some crops, i.e., sorghum and millet, are much more tolerant of drought conditions than others, e.g., maize, which need moisture at critical growth stages. Thus, farmers choose more drought tolerant crop types and varieties. They may also select varieties that have shorter growing seasons, or other characteristics that increase their ability to survive in the local environment.

In a given area some farmers will consistently achieve better yields than their neighbors. One of the keys to this success appears to be the ability to undertake operations, such as plowing, planting, and weeding in a timely manner. While management ability is an important factor in the timing of operations, it is also critical to have access to appropriate resources⁴ such as labor, traction and

related equipment, e.g., plows, at the opportune moment. Those farmers who control their resources, rather than having to rely on renting or sharing traction, are in a better position to improve the efficiency of the available water by making more water available to the plants at the time of germination and later for plant growth. They may do this by planting larger areas on the relatively good moisture following a rain, by performing a pre-planting cultivation to open the ground for moisture storage, or by following some type of water harvesting tillage scheme. The ability to improve water efficiency in these ways is often dependent on having extra resources available at a critical time.

Farmers undertake a number of traditional buffering strategies in their attempts to reduce the risks of farming in harsh agricultural environments. While it is possible for a farmer to improve crop germination by improving the timing of planting, the post-planting rainfall patterns are the major factor in determining how well the crop will yield. Unfortunately, the post-planting availability of moisture is generally a matter of luck. One traditional risk aversion mechanism is to stagger planting dates over a period of months. Staggered plantings are a management technique used to assure that at least some of the crop will be benefitted by each post-planting rain, and the strategy will thus provide at least a partial yield for the cropping season. Farmers who control their own traction can plant with each "planting rain" (i.e., a rainfall event of 10 or more mm in 24 hours), whereas those who must rely on hired tractors may be limited to the 1 or 2 days when the tractor is available for them. During this period there may be little or no soil moisture available, so the practice of using hired tractors that are available at the discretion of the tractor operator, rather than when the farmer needs the tractor, greatly increases the farmer's risk of a total crop failure. Farmers who share animal traction are also limited in the number of days they can plant on adequate soil moisture.

Farmers may buffer their cropping operation in at least two other ways.

- 1) First, they may invest a major share of their time and resources in livestock operations. For many semi-arid areas, extensive livestock operations are less risky than cropping enterprises. The generally lower risk of livestock enterprises and the usefulness of animal power in providing traction, added to the cultural importance which is often associated with livestock, means that many farmers choose to invest in livestock. However, particularly in large parts of the drier savanna areas in Africa, grazing areas are tribally controlled, with all of the associated problems of the "curse of the commons", which limits agriculturalists' ability to manage livestock most efficiently.

⁴It should be stressed that resources need to be appropriate for the semi-arid conditions faced by farmers. For example, tractor usage may not be appropriate for some types of semi-arid terrain as this type of traction may contribute to soil erosion

- 2) A second buffering approach is off-farm employment. In some countries, off-farm employment, either of the farmer or of other members of the family, buffers the farm operation so that funds are available to purchase food if necessary. In this situation the farm ceases to be a "subsistence" operation, i.e., the family goes hungry if they do not produce a certain minimum amount of crop, and becomes more of a "substitution" operation, i.e., the family substitutes any yield achieved from food crops for food that would have been purchased with funds derived from off-farm work or livestock sales. This practice frees funds for investment in other agricultural enterprises, often livestock, or investments such as improved housing.

Another major risk aversion strategy is for farmers to practice sequential decision making. Farmers make decisions, often on each individual plot planted on a particular rain, as the season progresses. This is analogous to a decision tree with each cropping activity, or crop stage, represented by a node. The farmer makes a decision at each node. These decisions depend primarily on the rainfall pattern to that point, the condition of the crop, and the farmer's expectations of future rainfall events. Thus, a farmer may make separate decisions to plant, weed, fertilize, or abandon individual plots, rather than treating the whole field as a unit. This type of sequential decision making allows the farmer flexibility in maximizing the efficient use of available resources by committing them to plots with the best potential for producing a yield. It also cuts losses by reducing work on, or abandoning, marginally productive plots.

Finally, the investment strategy that a farmer follows in his or her agriculture reflects a response that will reduce risk to an acceptable level for that individual. In the semi-arid areas it is common to find farmers following a strategy of minimizing investment in their riskiest enterprises, usually crops. They will often invest any extra funds in livestock rather than increasing investment in crops. A farmer's investment in a crop may consist of the required amount of seed--usually saved from a previous year--to plant the land, and other non-cash investments such as labor and use of owned traction, which may not have a high value alternative use. No cash investment will be made in fertilizer, pesticides, hired labor, or improved seed.

However, in the case of a high value crop, when the potential for cash returns is greater, there is more willingness to invest in seeds, fertilizer, and extra labor for land preparation, additional weeding, etc.⁵ For example, in Botswana cow peas are considered a high value crop as both the peas and the leaves are harvested for human consumption, and farmers normally invest more in sole-crop cow pea plots than in sorghum or millet plots

⁵The only irrigation on small farms we saw in Botswana was a hand-watered plot of a high value, illegal crop.

The traditional responses to constraints in harsh environments will often provide farming systems researchers with a starting point, and sometimes a set of limiting conditions, in their search for improved technologies.

IV. Implications for Farming Systems Research In a Harsh Environment.

One of the major differences between farming in a harsh environment and in one that is more amicable involves the amount of flexibility present in the farming system. Generally, in better environments, i.e., with more water more evenly distributed, there are flexibilities which can be exploited in developing improved technologies. For example, it may be possible to add a second crop if a shorter season variety is used for the first crop. In harsh environments, on the other hand, researchers often find that they must break constraints in order to improve the production potential for cropping. This may mean major investments such as developing irrigation systems or purchasing lumpy inputs such as tractors. Due to the lack of flexibility in agriculture in harsh environments, FSR in these environments tends to concentrate on constraint-breaking technologies, and thus is likely to be more costly, more time consuming, and require a higher level of participation of the policy and support systems in order to have these technologies successfully adopted.

A second implication for FSR involves the increased need for farmer participation. It is an axiom of FSR that farmer participation is always to be sought. Where the FSR is taking place in a harsh environment, this participation is even more critical because farmers tend to make decisions concerning the crop over the entire course of the cropping season, rather than following a standard technological package. Thus it is important that researchers are aware of farmer response to environment-experiment interactions throughout the entire period of an investigation. In this situation, farmer assessment of technologies will be an on-going process.

A consequence of farmers making decisions throughout the growing season, in a decision tree approach, is that researchers may need to consider a range of technology options at each of the decision points. For example, at a particular rainfall event farmers may decide to plow and plant, plow but wait to plant until a later rainfall event, or not plow at all. The second option, to plow and wait to plant at a later time, is a water harvesting strategy which proved successful in Botswana. However, exercising this option has implications for future decision nodes as a farmer will have to decide whether to plow and plant the previously plowed plot, or plow a new plot. Thus, researchers often have to develop a whole series of technologies which are options for a given set of environmental conditions at various points in the growing season.

Farmers working in harsh environments will, as in most other agricultural situations, display a great deal of heterogeneity in terms of resources at their

disposal, management skill, and their objectives for farming. It is important for FSR teams to recognize the existing heterogeneity in the area in which they are working. There are two ways that technological recommendations prepared for a heterogeneous audience can be improved.

- 1) Recommendations can be targeted for specific producer groups, usually differentiated by resources, i.e., a tillage system is more appropriate for use with animal power rather than tractor power or hand power.
- 2) Conditional information can be provided which indicates that a technology is most appropriate for use under specific circumstances, i.e., mechanical weeding technology is useful when row planting is used, but not with broadcast planting.

Often the targeting and conditional information is based on the best available estimates of how a technology can most effectively be used, and is thus subject to modification as more experience is gained with a particular technology. Having the technologies available, even if there remain questions to be investigated concerning their use, is usually preferable to waiting until all questions are answered before a technology is promoted by the extension organization.

Agricultural researchers may take an approach of developing a technology ladder, starting with less complex technologies and adding more complicated technologies as farmers progress "up the ladder". When working in a harsh environment there is considerable difficulty in using the technology ladder approach. This is because the technology ladder usually assumes that a relatively fixed environment and set of resources will be available to the farmer. More specifically the ladders are likely to be based on the assumption that a specific pattern of rainfall will be likely to occur. In a harsh environment this is not generally the case, so farmers must make decisions as the season progresses, rather than working with a given set of technologies for the entire season.

Working with agricultural development in a harsh environment may also mean that the usual measures of success for a technology, i.e., level of yield or level of return, may not be of primary concern to risk-averse farmers. Researchers may find that stability of return from a farming enterprise is considered to be more important than the level of return. We have found that farmers often would prefer a more certain, lower level of yield or return from an enterprise, than a high yield or return coupled with a higher risk of little or no return. In harsh environments high yields are possible, but may only happen under the best of conditions, i.e., one year in five or ten. Again, this is the type of information which can negatively affect the adoption of a technology, and is only going to be available to researchers if farmers are an integral part of the FSR process.

Another consequence of risk aversion is the tendency to minimize investment in new technologies. This implies that researchers need to work with technologies which are low cost, or that there needs to be some type of external

subsidy to encourage farmers to adopt a new, more expensive technology. In a harsh environment there is a chance that there will be a total failure in an enterprise, or a plot. Farmers' risk avoidance behavior is to minimize the risk of losing all of their investment, while maximizing the chance of an acceptable yield. Technologies which are expensive to implement may not be adopted because they are perceived as being too expensive in the local risk context, even if they do produce consistently higher yields. In this type of situation, the use of a subsidy to cover the expected loss, if it were to occur, can encourage adoption.

This draws attention to another very important aspect of doing FSR in a harsh environment, the importance of a strong relationship between the actual on-farm research activities and the policy and support system in the area. While the research and policy-support system linkages have often been neglected, they are of critical importance in working in a harsh environment. There are at least two reasons for this.

- 1) When working in a more hospitable environment, many changes exploit the flexibility in the environment. Often this type of change does not involve a major change in the farming system, and so can be financed by the farmer from available resources. However, in the harsh environment it is more likely that major technological changes to break constraints will have to be undertaken. Such technology changes are often too expensive to be undertaken by farmers using their own resources, and as noted above may need to be subsidized in order to assure adoption.
- 2) The support structures, i.e., marketing systems, extension systems, etc., also tend to be less well developed in harsh environments than in the more equitable environments. This follows from the lower population densities and lower productivity usually found in the harsh environment. Thus, even if technologies are improved for an area, if the marketing systems, extension system, and necessary support policies are not available, it is likely that little development will take place.

As Norman (1993) points out, several studies have concluded that a major cause of environmental degradation in environmentally fragile areas is poverty. As populations grow, the most limited resource segments tend to be pushed onto the most fragile lands. These farmers must often modify traditionally sustainable farming systems in order to maintain a minimum survival level of production. Unfortunately, these modifications are often environmentally destructive. Thus, for researchers working in harsh environments it is important to incorporate the concept of sustainability into their research activities. A part of this sustainability relates to developing appropriate technologies, i.e., technologies that are user-friendly to semi-arid regions. Through a strong farmer participation component

and strong linkages with policy and support systems, it may be possible for an FSR team to help balance long-run societal goals and short-run farmer goals, by working with technologies that will increase the sustainability of farming systems operating in harsh environments. An example of how this can work is the concept of a “stick and carrot”, e.g., if farmers wish to participate in a government program, such as destumping, then they must also participate in a program to improve the environment, such as planting hedge rows to reduce erosion.

V. Conclusions

Many low income countries in Africa, Asia and Latin America have areas which may be considered “harsh” environments for agricultural production due to lack of water. Unfortunately, population growth is putting pressure on these marginally productive areas through increased demand for crop land. FSR programs have increasingly been asked to work in these high risk areas. We believe that FSR can effectively contribute to agricultural development in harsh environments. Farmer participation in the research and strong linkages between research and policy-support systems are critical to the success of FSR in these areas. Other important factors for conducting research in harsh environments are the need to recognize special factors such as sequential decision making, heterogeneity in the target population, and the need for technology options. FSR projects in these areas must be closely linked to the local situation, but because harsh environments are also often fragile, it is incumbent on FSR teams to take special note of sustainability issues in their work.

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THE DISTRIBUTION OF MISSOURI BATS

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Abstract: Information about the distribution of bats in Missouri is limited. Hall's (1981) maps showed 14 species of bats in Missouri, most based on localities of record in other states. Schwartz and Schwartz (1981) provided excellent descriptions of those 14 species, but neither gave precise collecting localities within counties nor listed institutions where voucher specimens are deposited. Although numerous articles have subsequently been published on Missouri bats, the distribution of bats in the state remains poorly documented. In this paper we present distributional data for the 15 species of bats now known to occur in Missouri.

Methods and Materials

We compiled distribution data for 2,356 bat specimens available in Museums and other collections, and supplemented this information with literature and Missouri Department of Conservation records. In Table 1, county-specific data on the number of specimens of each species found in Museums are summarized. Map 1, and all subsequent species distribution maps, include all sources of information. Department of Conservation records are given only in maps, while published data are indicated in maps as well as listed in each species account as "additional records".

Presence or absence of each species in Missouri's three geographic regions (Map 2) and six natural divisions (Map 3) are summarized in Tables 2 and 3 respectively.

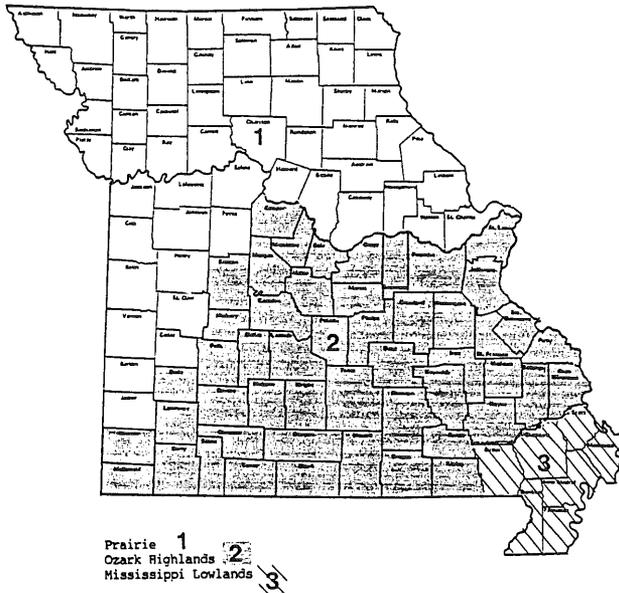
Abbreviations used for collections in which Missouri bat specimens are deposited are listed below (following Yates et al, (1987) where possible): American Museum of Natural History (AMNH); Arkansas State University (ASUMZ); Chicago Academy of Science (CHAS); Carnegie Museum of Natural History (CM); Central Missouri State University (CMSU); Field Museum of Natural History (FMNH); Florida State Museum, University of Florida (FSM); Gaylord Memorial Laboratory Museum (GML); Illinois Natural History Survey (INHS); Illinois State Museum (ISM); Museum of Natural History, University of Kansas (KU); Natural History Museum of Los Angeles County (LACM); Museum of Zoology, Louisiana State University (LSUMZ); Museum of Comparative Zoology, Harvard University (MCZ); Sternberg Museum of Natural History, Fort Hays State University (MHP); James Ford Bell Museum of Natural History, University of Minnesota (MMNH); Museum of Southwestern Biology, University of New Mexico (MSB); The Museum, Michigan State University (MSU); Museum

Table 1. Distribution of Missouri bats according to county records

Counties	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Adair			1	9	2	6	1	2	1	18						40
Atchison											2					2
Barry	14			1	6	2			18	5	2	1				49
Benton	1		1	2					3	4						11
Bollinger			1													1
Boone	106		62	4	40	13	1		36	43	3					308
Buchanan										1	1					2
Butler			1							3						4
Callaway									2							2
Camden	66		4		5			1	9							85
Cape Girardeau			1			10	1		1	3		2				18
Carter	1								1	1						3
Cass						1										1
Cedar						1										1
Christian					1				2	2						5
Clay									3	2						5
Clark						1										1
Cole						1				3						4
Crawford	1		10		6	1			3	4						25
Dallas									5							5
Douglas	1			5		1			114	19						140
Franklin	3		7	3	5	1			6	5						31
Gentry												1				1
Greene	7		1		1	2	1		7	9						28
Grundy			8	1	2	2	1	1		11						26
Harrison										1	4					5
Hickory	1								1							2
Holt						1					1					2
Howard					1					1						2
Iron		1	2		2				3	3						11
Jackson							2			5					1	8
Jasper										1						1
Jefferson			1			1				2						4
Johnson			1			1	1		2	11						16
Knox										6	1					7
Laclede	1		2		2	1				2						8
Lafayette						2					1					3
Lawrence	2								19	3						24
Lincoln										1						1
Linn									1							1
Macon						1				1						2
Madison	6	4	5	7	3	5			19	11						60
Marion					1				1	1						3
McDonald	4								22							26
Mercer					1	1	2					2				6
Miller	14			1	1	3			5	5			2			29
Mississippi									1			2				3
Moniteau	2															2
Montgomery			1													1
Morgan									1							1
Newton	3		1						2	2						8
Nodaway			1	1	8	19	6	11	1	11	117					175
Oregon								1	3	2						6
Ozark	2		2		1	1			1		1					8
Perry									1							1
Pettis						2										2
Phelps			3		8				3	5						19
Pike			1							2						3
Pulaski	220		92	20	97	10	2		67	16						524

Table 2. Distribution of Missouri bats according to the three geographic regions of Missouri

SPECIES	PRAIRIE	OZARK HIGHLANDS	MISSISSIPPI LOWLANDS
<i>M. grisescens</i>	X	X	X
<i>M. leibii</i>		X	
<i>M. lucifugus</i>	X	X	X
<i>M. septentrionalis</i>	X	X	
<i>M. sodalis</i>	X	X	X
<i>L. borealis</i>	X	X	X
<i>L. cinereus</i>	X	X	
<i>L. noctivagans</i>	X	X	X
<i>P. subflavus</i>	X	X	X
<i>E. fuscus</i>	X	X	X
<i>N. humeralis</i>	X	X	X
<i>P. rafinesquii</i>		X	
<i>P. townsendii</i>		X	
<i>T. brasiliensis</i>	X	X	
<i>N. macrotis</i>		X	
TOTAL	11	15	8



Map 2: Geographic regions of Missouri

Table 3. Distribution of Missouri bats according to the six natural divisions of Missouri

SPECIES	1	2	3	4	5	6
<i>M. grisescens</i>	X	X	X	X	X	X
<i>M. leibii</i>					X	
<i>M. lucifugus</i>	X	X	X		X	X
<i>M. septentrionalis</i>	X	X	X		X	
<i>M. sodalis</i>	X	X	X		X	
<i>L. borealis</i>	X	X	X	X	X	X
<i>L. cinereus</i>	X	X	X	X	X	
<i>L. noctivagans</i>		X	X		X	X
<i>P. subflavus</i>	X	X	X	X	X	X
<i>E. fuscus</i>	X	X	X	X	X	X
<i>N. humeralis</i>	X	X	X	X	X	X
<i>P. rafinesquii</i>			X		X	
<i>P. townsendii</i>					X	
<i>T. brasiliensis</i>		X			X	
<i>N. macrotis</i>			X			
TOTAL	9	11	12	6	14	7

Key to columns: (1) Big rivers, (2) Glaciated plains, (3) Ozark border, (4) Osage plain, (5) Ozark, (6) Mississippi lowland



Map 3. Natural Divisions of Missouri: (1) Big Rivers; (2) Glaciated Plains; (3) Ozark Border; (4) Osage Plains; (5) Ozark; (6) Mississippi Lowlands (Thom and Wilson, 1980).

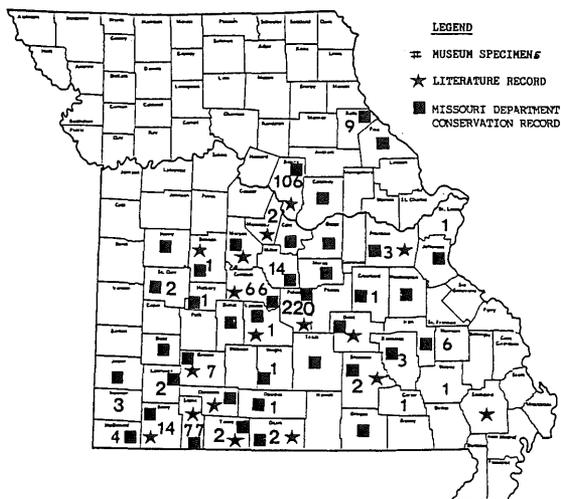
of Zoology, Memphis State University (MSUMZ); Missouri Southern College (MSSC); Collection of Recent Mammals, Midwestern State University (MWSU); Northeast Missouri State University (NEMSU); Northwest Missouri State University (NWMSU); National Museum of Natural Sciences, Canada (NMC); Oklahoma State University (OSU); Oklahoma Museum of Natural History, University of Oklahoma (OU); Pittsburg State University (PSUMC); Southeast Missouri State University (SEMSU); Southern Illinois University-Carbondale (SIUCM); The Vertebrate Museum, Shippensburg University (SUVU); Southwest Missouri State University (SWMSU); Texas Cooperative Wildlife Collection, Texas A&M University (TCWC); Tyson Biological Research Center, Washington University (TBRC); Tarleton State Collection, Tarleton State University (TSC); The Museum, Texas Tech University (TTU); Museum of Natural History, University of Illinois (UIMNH); Museum of Zoology, University of Michigan (UMMZ); University of Missouri-St. Louis (UMSL); Museum of Zoology, University of Missouri (UNMZ); National Museum of Natural History (USNM/FWS); Westminster College (WC); William Jewel College, (WJC); Webster Natural History Museum, Oklahoma Baptist University (WNHM).

Vernacular names in species accounts are those used by Jones, et al. (1992). Counties are listed alphabetically.

Myotis grisescens, gray bat (Map 4).

Specimens examined: (558). No specific locality, 5(2CMSU, 3WNHM); Barry Co.: Exeter, 1(UMMZ), 7 mi E Cassville, Rockhouse Cave, 13(AMNH); Benton Co.: 6 mi SE Lincoln, 1(UNMZ); Boone Co.: No specific locality, 2(WJC), Columbia, 6(3NEMSU, 1GML, 2WJC), 10.5 mi W. Columbia, Rocheport Cave, 82(2LSUMZ, 3NEMSU, 3UIMNH, 3UIUC, 70UNMZ, 1SWMSU), 7 mi SW Columbia, Devil's Ice Box Cave, 1(UNMZ), Easley, 1(WJC) Hunter's Cave, 2(1TCWC, 1UNMZ), Rocheport, 2(1NEMSU, 1CMSU), 8 mi from Rocheport, 10(FMNH); Camden Co.: No specific locality, 55(NMC), Camdenton, Winter Cave, 1(UNMZ), Climax Spring, Mauss Cave, 4(2CMSU, 2LSUMZ), Lake of Ozarks, 1(UNMZ), Montreal, 4(CMSU), Wet Glaize, Carrel Cave, 1(UNMZ); Carter Co.: Big Spring State Park, 1(USNM/FWS); Crawford Co.: Boulder Cave, 1(UNMZ); Douglas Co.: 1.8 mi SW Evans, Brown's Cave, 1(TCWC); Franklin Co.: Stanton, Mystery Cave, 3(FMNH); Greene Co.: 14 mi E Cape Fair, 5(SWMSU), 8 mi S & 3 mi W 160 & M Hwys, 2(SWMSU); Hickory Co.: Hermitage, 1(CMSU); Lawrence Co.: 1 mi. N. Stinson, 1(ISM), Turnback Cave, 1(UM); Laclede Co.: Lebanon, 1(CMSU); Madison Co.: 4 mi N Fredericktown, 6(ASUMZ); McDonald Co.: 5 mi SW Noel, 1(PSUMC), 3 mi S Noel, 1(CM), Powell, 1(PSUMC), Saltpetre Cave, 1(KU); Miller Co.: No specific locality, 1(CMSU), 2 mi S, 5 mi W Iberia, 13(FMNH); Moniteau Co.: Tipton, 1(UMSL), 5 mi E Tipton, 1(NEMSU); Newton Co.: 5 mi E Joplin, cave, 1(MSSC), 4.5 mi NE Neosho, 1(PSUMC), 4 mi SE Sarcoxie, 1(KU); Ozark Co.: 10 mi NW Gainesville,

1(SWMSU), 1 mi S Sycamore, Russell's Cave, 1(FMNH); Pulaski Co.: No specific locality,



Map 4. Distribution of the gray bat, *Myotis grisescens*

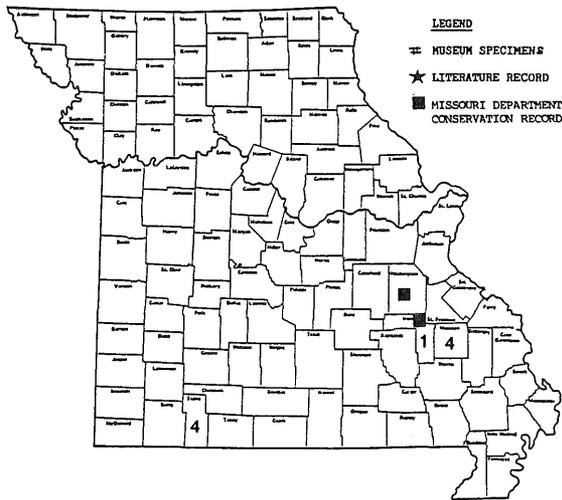
56(3CMSU, 53MSB), Bat Cave, 1(ISM), 3 mi NE Big Piney, Miller Cave, 1(FMNH), 4 mi S Crocker, Wind Tunnel Cave, 41(18CM, 21NHS, 1ISM, 9UIMNH, 11UIUC), Dixon, 1(CMSU), Guano Cave, 2(MHP), T37 N, R 12 W, 25 mi SE Sec 33, 110(MHP), Waynesville, 8(CMSU); Ralls Co.: NW Frankford, Fisher's Cave, 5(SIUCM), Frankford, 1(SWMSU), Frankford Cave, 3(UNMZ); Reynolds Co.: Bees, 3(UNMZ); St. Louis Co.: Tyson Research Area, 1(TBRC); Shannon Co.: Alley Spring, 1(WJC), 2 mi NW Round Spring, Bat Cave, 1(TCWC); St. Clair Co.: Monagaw Springs Cave, 2(UNMZ); Stone Co.: 9 Mi SW Branson, 35(21OU, 5UIMNH, 1UNMZ, 8SWMSU), 8.2 mi E, 2.75 mi N Hermitage, 2(SWMSU), 5.14 mi SE Hurley, 8(SWMSU), 2 mi S Kimberlin, 3(MSUMZ), Marvel Cave, 20(9MMNH, 4MSB, 2UIUC, 1UMSL, 1UMMZ, 3USNM/FWS), Reeds Spring, 9 mi SW Marvel Cave, 9(1FSM, 5USNM/FWS, 3SEMSU); Taney Co.: Rueter, 2(CMSU); Wayne Co.: 2 mi E Patterson, 1(UNMZ); Wright Co.: 0.5 mi E Mansfield, 1(SWMSU).

Additional records: Barry Co.: Viola, Kings River (Elder and Gunier, 1978); Benton Co.: cave (Elder and Gunier, 1978); Boone Co.: cave (Elder and Gunier, 1978); Camden Co.: Grandpa Chipley's Cave (Easterla, 1967) a cave (Elder and Gunier, 1978); Christian Co.: Highlandville (Elder and Gunier, 1978); Dent Co.: cave (Clark, et al., 1978) Franklin Co.: two caves (Clark, et al., 1978),

Meramec Park Lake (LaVal, et al., 1977); Greene Co.: cave (Elder and Gunier, 1978); Laclede Co.: cave (Elder and Gunier, 1978); Moniteau Co.: Tipton Barn (Elder and Gunier, 1978); Morgan Co.: cave (Elder and Gunier, 1978); Ozark Co.: cave (Elder and Gunier, 1978); Shannon Co.: no specific locality (Gunier and Elder, 1971); Stoddard Co.: Mingo National Refuge, Puxico (Easterla, 1967); Stone Co.: Marvel Cave (Elder and Gunier, 1978 and 1981); Taney Co.: localities near Branson (Elder and Gunier, 1978), Ozark underground laboratory (Elder and Gunier, 1978).

Myotis leibii, eastern small-footed bat (Map 5).

Specimens examined: (9). Iron Co.: 3 mi S Graniteville, 1(UIMNH); Madison Co.: Saltpetre Cave, 4(3ASUMZ, 1MSUMZ); Stone Co.: Marvel Cave, 4(1MSUMZ, 2UNMZ, 1UMSL).

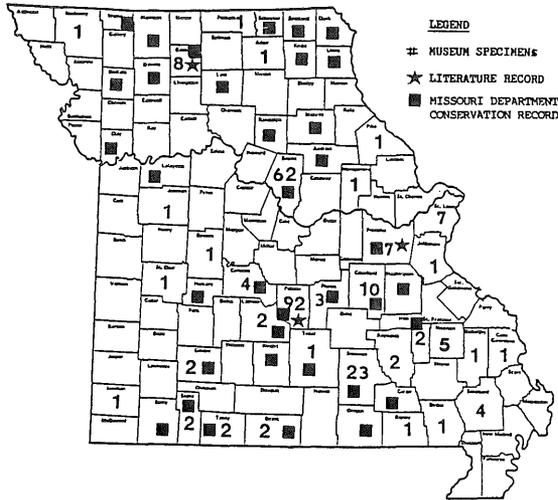


Map 5. Distribution of the eastern small-footed bat, *Myotis leibii*

Myotis lucifugus, little brown bat (Map 6).

Specimens examined: (339). Missouri: No specific locality, 86(MCZ); Adair Co.: Kirksville, 1(NEMSU); Benton Co.: Edwards, 1(CMSU); Bollinger Co.: Duck Creek Wildlife Refuge, 1(UMSL); Boone Co.: No specific locality, 17(1CMSU, 12WC, 4WJC), 10.5 mi W Columbia, Rocheport Cave, 32(2AMNH, 3CM, 4FMNH, 5OSU, 2SWMSU, 15UNMZ, 1USNM/FWS), Columbia, 4(1CMSU, 3WJC), 7 mi SW Columbia, Devils Ice Box Cave, 1(UNMZ), Easley, 2(WJC), Hunter's Cave, 4(2GML, 2UNMZ); Rocheport, Boone Cave,

2(1NEMSU, 1UNMZ); Butler Co.: Keener’s Cave, 1(UNMZ); Cape Girardeau Co.: Cape Girardeau, 1(SIUCM); Camden Co, Camdenton, 1(CMSU), Ha Ha Tonka State Park, 1(CAS), Wet Glaizer, Carrel Cave, 1(UNMZ), Windermere, 1(WJC); Crawford Co.: 6.3 mi SE Bourbon, 1(LSUMZ), Leasburg, 9(CAS);



Map 6. Distribution of the little brown bat, *Myotis lucifugus*

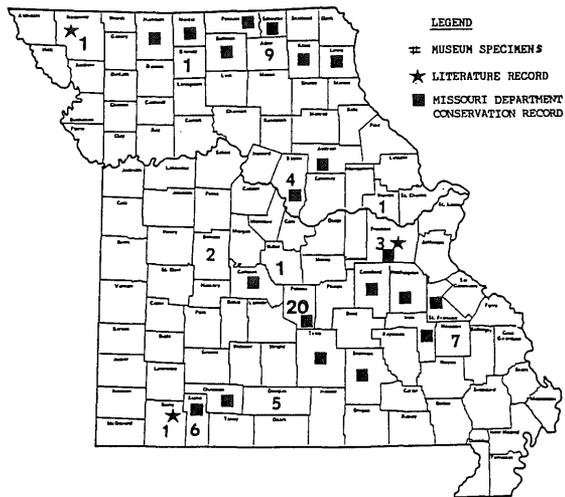
Franklin Co.: Fisher Cave, 1(UNMZ), Meramec State Park, Meramec Cavern, 1(LACM), Mushroom Cave, 4(UNMZ), Mystery Cave near Slater, 1(FMNH), 1(CMSU); Greene Co.: 8 mi N Springfield, Crystal Cave, 1(KU); Grundy Co.: 8 mi W Spickard, 7(KU), 7.5 mi W Spickard, 1(KU); Iron Co.: Pilot Knob, Pilot Knob Iron Mine, 2(UMMZ); Jefferson Co.: No specific locality, 1(TBRC); Johnson Co.: Warrensburg, 1(CMSU); Laclede Co.: Eldridge, 2(CMSU); Madison Co.: 14 mi N Fredericktown, 3(ASUMZ), 4 mi N Fredericktown, 1(ASUMZ), Fredericktown, 1(ASUMZ); Montgomery Co.: Montgomery City, 1(USNM/FWS); Newton Co.: NW Joplin, Ku Klux Klan Cave, 1(MSSC); Ozark Co.: Gainesville, 2(CMSU); Phelps Co.: 2 mi N, 2 mi W Jerome, 1(UMMZ), Saltpetre Cave, 1(UNMZ), T38N, R9W, N14 SE 0.25 Sec 8, 1(MHP); Pike Co.: No specific locality, 1(WJC); Nodaway Co.: Maryville Area, 1(NWMSU); Pulaski Co.: No specific locality, 7(3CMSU, 4ISM), Big Piney, 1(CMSU), 4 mi S Crocker, William’s Bat Cave, 8(CM), 4 mi S Crocker, Wind Tunnel Cave, 6(MHP), 4.5 mi S Crocker, Gasconade River, Bat Cave, 60(NEMSU), Dixon, 2(CMSU), Ft Leonard Wood, School House Cave, 1(UNMZ), Maxey (Inca) Cave, 5(ISM), Waynesville, Bat Cave, 2(1CMSU, 1UNMZ); Putnam Co.: No specific locality, 1(MSU); Reynolds

Co.: Bees Low Gap Refuge, 2(UNMZ); Ripley Co.: Louis' Cave, 1(UNMZ); St Clair Co.: 3 mi E Monaegaw, 1(KU); St Louis Co.: Tyson Research Area, 6(TBRC), University City, 1(TBRC); Shannon Co.: 0.5 km N, 7 km W Eminence, 22(UNMZ), 0.5 mi E Owls Bend, 1(KU); Stoddard Co.: No specific locality, 1(NEMSU), Gaylord Wildlife Refuge, 3(UNMZ); Stone Co.: 4 mi N, 1 mi E Reeds Spring, Old Spanish Cave, 1(KU), 5.5 mi S Reeds Spring, Mud Cave, 1(CM); Texas Co.: Arroll, 1(UNMZ); Taney Co.: Rockaway Beach, 2(KU).

Additional records: Franklin Co.: Meramec Park Lake (LaVal, et al., 1977); Grundy Co.: 12 Km W Spickard (Watkins and Shump Jr., 1981); Pulaski Co.: Inca cave (Myers, 1960).

Myotis septentrionalis, northern bat (Map 7).

Specimens examined: (61). Adair Co.: No specific locality, 2(FMNH), Kirksville, 6(NEMSU), 5 mi S, 1 mi E Kirksville, 1(NEMSU); Barry Co.: Casper, Roaring River State Park, 1(NWMSU); Benton Co.: 6 mi SE Lincoln, Cole Camp



Map 7. Distribution of the northern myotis, *Myotis septentrionalis*

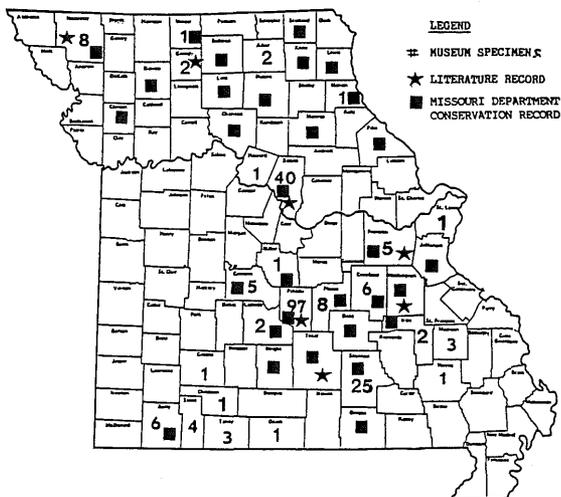
Creek Cave, 2(UNMZ); Boone Co.: 10.5 mi W Columbia, Rocheport Cave, 4(3UNMZ, 1USNM/FWS); Douglas Co.: 1.8 mi SW Evans, Brown's Cave, 5(1TCWC, 2TSC, 2UIUC); Franklin Co.: Meramec State Park, Bear Cave, 1(KU), Fisher Cave, 1(UNMZ), Mushroom Cave, 1(UNMZ); Grundy Co.: 7.5 mi W Spickard, 1(KU); Madison Co.: 14 mi N Fredericktown, 4(ASUMZ), 4 mi N Fredericktown, 1(AUMZ), Saltpetre Cave, 2(ASUMZ); Miller Co.: 2 mi S, 0.5 mi N Iberia, 1(UNMZ); Nodaway Co.: 4 mi SE Maryville, 1(NWMSU); Pulaski Co.:

Dixon, Piquet Cave, 1(UNMZ), Fort Leonard Wood, School House Cave, 4(2UIMNH 2UIUC), Grinshinski Cave 1(UNMZ), Maxeys (Inca) Cave, 11(10ISM, 1LSUMZ), Onyx Cave, 1(UNMZ), Waynesville, 2(CMSU), 8 mi S Waynesville, Berry Cave, 2(1UIMNH, 1UIUC); Stone Co.: Fairy Cave, 1(UNMZ), Marvel Cave, 4(1OU, 3OUSNM/FWS), 5.5 mi S Reeds Spring, Mud Cave, 1(CM); Warren Co.: 6 mi S Jonesburg, 1(NEMSU).

Additional records: Barry Co.: Roaring River State Park (Easterla, 1968); Franklin Co.: Meramec Park Lake (LaVal, et al., 1977); Nodaway Co.: 4 mi SE Maryville (Easterla and Watkins, 1969).

Myotis sodalis, Indiana bat (Map 8).

Specimens examined: (235). Missouri, No specific locality, 8(CMSU), Adair Co.: 2 mi N Kirksville, 1(NEMSU), Kirksville, 1(NEMSU); Barry Co.: Casper, Roaring River State Park, 2(UNMZ), Cassville, 2(UMMZ), 7 mi E Cassville, Rockhouse Cave, 1(UNMZ), Wheeler, Koch's Cave, 1(USNMZ); Boone Co.: No specific locality, 5(1AMNH, 2USNM/FWS, 2WJC), 10.5 mi W Columbia, Rocheport Cave, 30(2CM, 3FMNH, 1LSUMZ, 2SIUCM, 22UNMZ), Columbia, 2(1NEMSU, 1UNMZ), Hunter's Cave, 2(UNMZ), 1 mi N Midway, McCrory Cave, 1(UNMZ); Camden Co.: Camdenton, Water Cave, 1(UNMZ), Stoutland, 1(UNMZ), Wet Graize, Carrel Cave, 3(1SIUCM, 2UNMZ); Christian Co.: Smallin's Cave, 1(UNMZ); Crawford Co.: Boulder Cave, 1(UNMZ), 6.3 mi SE



Map 8. Distribution of the Indiana bat, *Myotis sodalis*

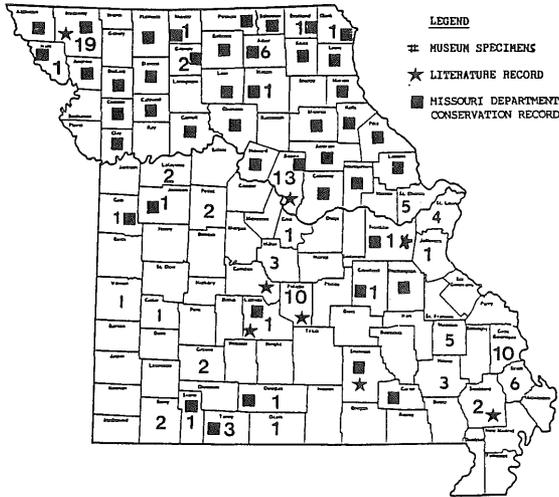
Bourbon, 5(LSUMZ); Franklin Co.: Meramec State Park, Bear Cave, 5(1KU, 4UNMZ), Greene Co.: 14 mi E. Cape Fair, 1(SWMSU); Grundy Co.: 8 mi W Spickard, 2(KU); Howard Co.: No specific locality, 1(LSUMZ); Iron Co.: Pilot Knob, Pilot Knob Iron Mine, 2(UNMZ); Laclede Co.: Bennett Spring, Cat Hollow Cave, 1(UNMZ), Eldridge, Mary Lawson Cave, 1(UNMZ); Madison Co.: Saltpetre Cave, 3(USNM/FWS); Marion Co.: White Bear, Limestone Cave, 1(UNMZ); Mercer Co.: 1 mi N, 3.5 mi W Modera, 1(TTU); Miller Co.: No specific locality, 1(FMNH); Nodaway Co.: 2 mi SE Arkoe, 1(NWMSU), 4 mi SE Maryville, 1(NWMSU), 6 mi S Maryville, 6(NWMSU); Ozark Co.: Gainesville, Beaver Cave, 1(UNMZ); Phelps Co.: 2 mi N, 2 mi W Jerome, 2(UMMZ), Saltpetre Cave, 6(MHP); Pulaski Co.: No specific locality, 4(2CMSU, 1ISM, 1UNMZ), Big Piney, Ryden's Cave, 10(4CMSU, 6UNMZ), 4 mi S Crocker, William's Bat Cave, 21(8CM, 6INHS, 7UIMNH), Wind Tunnel Cave, 12(2MHP, 8UIMNH, 2UM), Dixon, 1(CMSU), Piquet Cave, 3(MHP), Duke, 4(CMSU), Ft Leonard Wood, School House Cave, 1(UIMNH), 10 mi S Newburg, Ross Cave, 1(OSU), 5.3 mi SE Richland, Richland Cave, 1(LSUMZ), Waynesville, 3(CMSU), 5 mi S Waynesville, Maxey (Inca) Cave, 34(10CM, 4ISM, 20UIMNH), 8 mi S Waynesville, Barry Cave, 2(UIMNH); St. Louis Co.: Tyson Research Area, 1(TBRC); Shannon Co.: 15 mi N. Eminence, Bat Cave, 2(FSM), 4.5 mi NW Round Spring, 11(LSUMZ), 2.5 mi NW Round Spring, Bat Cave, 8(4TCWC, 4UIMNH), 4 mi N Round Spring, 4(TCWC); Stone Co.: Fairy Cave, 2(UNMZ), Marvel Cave, 1(OU), 4 mi N, 1 mi E Reeds Spring, Old Spanish Cave, 1(KU); Taney Co.: Branson, Marvel Cave, 1(UNMZ); Washington Co.: 6 mi E Anthonies' Mill, 2(UMMZ); Wayne Co.: 3 mi W Patterson, Yancey's Cave 1(UNMZ).

Additional records: Boone Co.: Rochport Cave (Easterla and Watkins, 1969); Franklin Co.: Meramec Park Lake (LaVal, et al., 1977); Grundy Co.: 12 km W Spickard (Watkins and Shump Jr., 1981) Nodaway Co.: 6 mi S Maryville (Easterla and Watkins, 1968); Pulaski Co.: Inca Cave (Myers, 1960); Texas Co.: Upper Jack's Fork River (Cary and Clawson, 1981); Washington Co.: Great Scott Cave (Brack, Jr. and LaVal, 1985).

Lasiurus borealis, eastern red bat (Map 9).

Specimens examined: (117). Missouri: No specific locality, 1(MCZ); Adair Co.: Kirksville, 6(NEMSU); Barry Co.: Casper, Roaring River State Park, 1(UNMZ), 7 mi E Cassville, Rockhouse Cave, 1(CM); Boone Co.: 10.5 mi W Columbia, Rocheport Cave, 1(UNMZ), Columbia, 9(2ISM, 7UNMZ), Hartsburg, 2(UNMZ), Lewis and Clark Cave, 1(UNMZ); Cape Girardeau Co.: No specific locality, 6(SEMSU), Cape Girardeau, 3(2SEMSU, 1UNMZ), 0.7 mi W Crump, 1(SEMSU); Cass Co.: Harrisonville, 1(MWSU); Cedar Co.: Stocktown, 1(UNMZ); Clark Co.: 0.5 mi E Reeves, 1(NEMSU); Cole Co.: Jefferson City, 1(UNMZ); Crawford Co.: Leasburg, 1(CHAS); Douglas Co.: Willow Spring, 1(UMSL); Franklin Co.: Meramec State Park, 1(UNMZ); Greene Co.: Springfield, 1(SWMSU), 0.5 mi S fairground, Springfield, 1(ISM); Grundy Co.: 8 mi W

Spickard, 1(KU), 7 mi W Spickard, 1(TTU); Holt Co.: No specific locality, 1(USNM/FWS); Jefferson Co.: Hegeman Rd & Hwy 21, 1(UMSL); Johnson Co.:



Map 9. Distribution of the eastern red bat, *Lasiurus borealis*

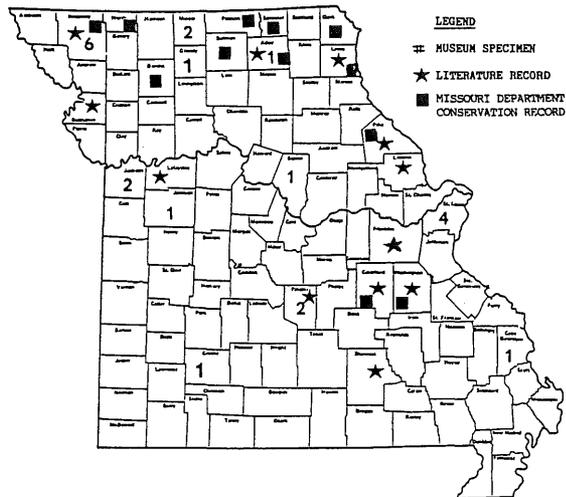
No specific locality, 1(ISM); Laclede Co.: Lebanon, 1(UNMZ); Lafayette Co.: Higginsville, 2(UMSL); Macon Co.: Macon, 1(UNMZ); Madison Co.: 2 mi N Fredericktown, 3(ASUMZ), 0.5 mi N Fredericktown, 1(ASUMZ), Fredericktown, 1(ASUMZ); Mercer Co.: 0.75 mi W, 7 mi W Spickard, 1(KU); Miller Co.: 2 mi S, 0.5 mi W Iberia, 3(FMNH); Nodaway Co.: 2 mi SE Arkoee, 1(NWMSU), 6 mi SE Maryville, 2(USNM/FWS), 4 mi S, 2 mi W Maryville, 2(KU), 6 mi S Maryville, 14(NWMSU); Ozark Co.: 7 mi S Thornfield, 1(TSC); Pettis Co.: Sedalia, 2(UNMZ); Pulaski Co.: No specific locality, 1(ISM), Crocker, Bat Cave, 1(UNMZ), 4 mi S Crocker, Wind Tunnel Cave, 1(UNMZ), Inca Cave, 5(ISM), Waynesville, Bat Cave, 2(UNMZ); St. Charles Co.: Webster Groves, 4(UMMZ), Weldon Spring Military Training Area, 1(MHP); St. Louis Co.: St. Louis, 1(FMNH), Tyson Research Area, 3(TBRC); Stoddard Co.: Puxico, Mingo National Wildlife Refuge, 2(IGML, 1NWMSU); Scotland Co.: Memphis, 1(NEMSU); Scott Co.: 1.5 mi SE Oran, 6(LSUMZ); Stone Co.: 5.5 mi S Reeds Spring, 1(CM); Taney Co.: Branson, 2(KU), 6 mi N Rockaway Beach, 1(KU); Vernon Co.: 2 mi E Nevada, 1(SWMSU); Wayne Co.: 10 mi S Greenville, Otter Creek, 2(UNMZ), Piedmont, Clearwater Dam, 1(UNMZ).

Additional records: Boone Co.: Hunter's Cave (Myers, 1960); Camden Co.: cave (Myers, 1960); Franklin Co.: Meramec Park Lake (LaVal, et al., 1977);

Laclede Co.: Bat Cave (Myers, 1960); Nodaway Co.: 2 mi SE Arkoe (Easterla and Watkins, 1969); Pulaski Co.: numerous caves (Myers, 1960); Shannon Co.: (Easterla, 1965), Powder Mill Cave (Myers, 1960); Stoddard Co.: Mingo National Wildlife Refuge, Puxico (Easterla, 1967).

Lasiurus cinereus, hoary bat (Map 10).

Specimens examined: (23). Missouri: No specific locality, 1(CMSU); Adair Co.: Kirksville, 1(NEMSU); Boone Co.: Columbia, 1(UNMZ); Cape Girardeau Co.: Cape Girardeau, 1(UNMZ); Greene Co.: Springfield, 1(SWMSU); Grundy Co.: 8 mi W Spickard, 1(KU); Jackson Co.: Blue Spring, 1(CMSU), Kansas City, 1(KU); Johnson Co.: Warrensburg, 1(CMSU); Mercer Co.: No specific locality, 2(MSU); Nodaway Co.: 6 mi SW Maryville, 6(4NWMSU, 1SEMSU, 1USNM/FWS); Pulaski Co.: No specific locality, 1(LSUMZ), Waynesville, Bat Cave, 1(UNMZ); St. Louis Co.: No specific locality, 2(USNM/FWS), Ladue, 1(TBRC), Tyson Research Area, 1(TBRC).



Map 10. Distribution of the hoary bat, *Lasiurus cinereus*

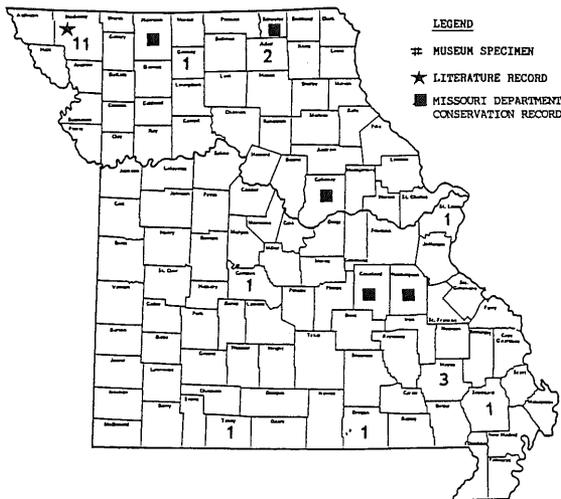
Additional records: Adair Co.: (Choromanski-Norris and Fritzell, 1983); Buchanan Co.: (Choromanski-Norris and Fritzell, 1983); Crawford Co.: (Choromanski-Norris and Fritzell, 1983); Franklin Co.: Meramec Park Lake (Laval, et al., 1977); Lafayette Co.: (Choromanski-Norris and Fritzell, 1983); Lewis Co.: (Choromanski-Norris and Fritzell, 1983); Lincoln Co.: (Choromanski-Norris and Fritzell, 1983); Nodaway Co.: 6 mi S Maryville (Easterla and Watkins, 1969 and 1970); Pike Co.: (Choromanski-Norris and Fritzell, 1983); Pulaski Co.: numerous

caves (Myers, 1960); Shannon Co.: Powder Mill Cave (Myers, 1960); Washington Co.: (Choromanski-Norris and Fritzell, 1983).

Lasionycteris noctivagans, silver-haired bat (Map 11).

Specimens examined: (22). Adair Co.: Kirksville, 2(NEMSU); Camden Co.: Camdenton, 1(FMNH); Grundy Co.: 8 mi W Spickard, 1(KU); Nodaway Co.: No specific locality, 8(NWMSU), Bolekow, 1(ISM), 4 mi SE Maryville, 1(USNM/FWS), 6 mi S Maryville, 1(NWMSU); Oregon Co.: No specific locality, 1(CMSU); St. Louis Co.: Overland, 1(TSC); Stoddard Co.: No specific locality, 1(UNMZ); Taney Co.: Branson, Marvel Cave, 1(UNMZ); Wayne Co.: Piedmont, Clearwater Dam, 1(UNMZ), Williamsville, 2(UNMZ).

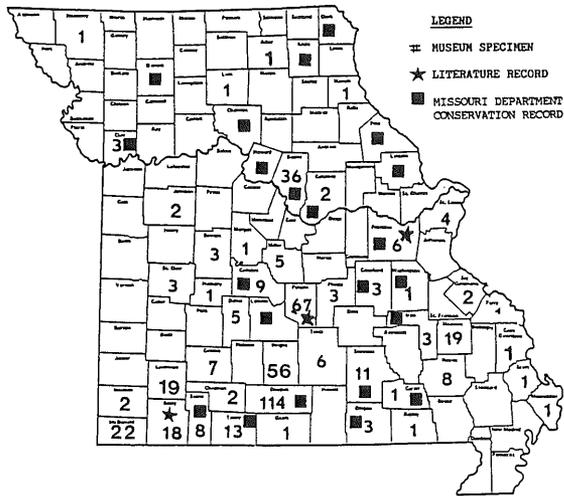
Additional records: Nodaway Co.: 6 mi S Maryville, (Easterla and Watkins, 1969 and 1970).



Map 11. Distribution of the silver-haired bat, *Lasionycteris noctivagans*

Pipistrellus subflavus, eastern pipistrel (Map 12).

Specimens examined: (519). Missouri: No specific locality, 41(3CMSU, 38MCZ); Adair Co.: Kirksville, 1(NEMSU); Barry Co.: Casper, Roaring River State Park, 4(2UNMZ, 2NWMSU), Cassville, 1(UMMZ), 7 mi E Cassville, Rockhouse Cave, 2(1AMNH, 1UIMNH), 8 mi S, 5 mi E Cassville, 3(MHP), 10 mi SW Cassville, 1(PSUMC), Exeter, 7(UMMZ); Benton Co.: Duo Rock, Estes Cave,



Map 12. Distribution of the eastern pipitrel, *Pipistrellus subflavus*

1(NEMSU), Edward, 2(CMSU); Boone Co.: No specific locality, 4(WJC), 10.5 mi W Columbia, Rocheport Cave, 17(1CM, 4LSUMZ, 12UNMZ), Columbia, 3(WJC), S Columbia, 1(SEMSU), 10 mi S Columbia, 1(NEMSU), Columbia, Polly's Pot Cave, 1(NEMSU), Hunter's Cave, 7(2SIUCM, 4UNMZ, 1WJC), Easley, 1(WJC), Joy Cave, 1(UNMZ); Cape Girardeau Co.: 0.7 mi W Crump, 1(SEMSU); Camden Co.: Barnumton, Firey Forks Cave, 1(UNMZ), Camdenton, 7(1CMSU, 6FMNH), T38N,R17W, 1(WJC); Calloway Co.: 2 mi W, 2 mi S Gutheri, 2(WC); Carter Co.: Van Buren, 1(UMMZ); Christian Co.: 3m E Ozark, 1(UMMZ), Garrison Cave, 1(UNMZ); Clay Co.: Excelsior Spring, 2(CSMU), Sullivan, 1(CAS); Crawford Co.: Boulder Cave, 2(UNMZ), 6.3 mi SE Bourbon, 1(LSUMZ); Dallas Co.: Saltpetre Cave, 4(GML), Windyville, 1(CMSU); Franklin Co.: Meramec State Park, Bear Cave, 4(UNMZ), Fisher Cave, 1(UNMZ), Mushroom Cave, 1(UNMZ); Douglas Co.: 1.8 mi SW Evans, Brown's Cave, 114(48MHP, 4SUV, 61TCWC, 1TSC); Green Co.: Ash Grove, 1(SWMSU), 8 mi N, 15 mi. E Springfield, 2(SWMSU), Springfield, 2(CMSU), 8 mi S, 3 mi W 60 & M Hwy, 1(SWMSU), Sequoia Park Cave, 1(SWMSU); Hickory Co.: Elkton Cave, 1(UNMZ); Iron Co.: Pilot Knob, Pilot Knob Iron Mine, 3(1SIUCM, 1TTU, 1UNMZ); Johnson Co.: No specific locality, 1(ISM), Warrensburg, 1(CMSU); Lawrence Co.: 35 mi W Halltown, Turnback Cave, 1(FMNH); 2 mi S, 0.5 mi W Iberia, Miller's Cave, 18(FMNH); Linn Co.: Brookfield, 1(UNMZ); Madison Co.: 14 mi N Fredericktown, 3(ASUMZ), 1 mi NE Fredericktown, 2(ASUMZ), 5 mi SE Fredericktown, 1(ASUMZ), 21 mi SW Fredericktown, 1(ASUMZ), Saltpetre Cave, 9(ASUMZ), Spring House Cave, 1(ASUMZ), Still House Cave, 2(ASUMZ);

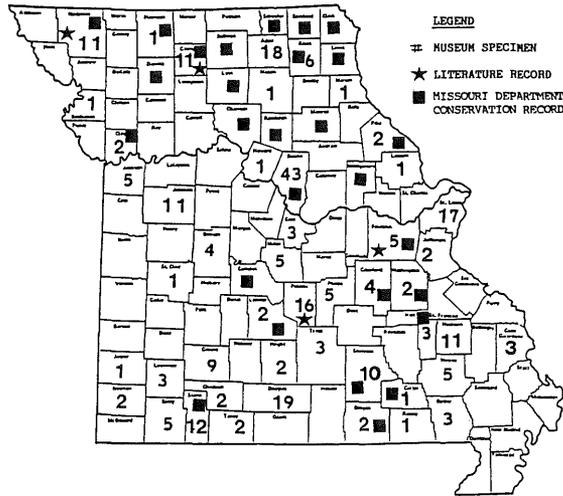
Marion Co.: No specific locality, 1(UNMZ); McDonald Co.: No specific locality, 2(PSUMC), Cyclone, 1(PSUMC), 1 mi N Jane, 5(PSUMC), 3 mi S Noel, 1(CM), Pineville, 1(WNHM), 5 mi S Pineville, 1(PSUMC), 2.5 mi SW Pineville, 2(MHP), 8 mi S Pineville, 7(WNHM), Saltpetre Cave, 1(UNMZ); Miller Co.: 3 Mi S Sheldon, 1(UM), St Elizabeth, 4(CMSU); Mississippi Co.: East Prairie, 1(UIMNH); Morgan Co.: Versailles, Dry Branch Cave, 1(NEMSU); Newton Co.: Camp Crowder, 1(SWMSU), NW Joplin, Klu Klux Klan Cave, 1(MSSC); Nodaway Co.: No specific locality, 1(NWMSU); Oregon Co.: no specific locality, 2(CMSU), Bat Cave, 1(UNMZ); Ozark Co.: 7 mi S Thornfield, 1(TSC); Perry Co.: 5 mi N Perryville, 1(UNMZ); Phelps Co.: Saltpetre Cave, 1(MHP), 2 mi S, 2.5 mi W Vida, 2(MHP); Pulaski Co.: Big Piney, 11(CMSU), 5 mi S Crocker, Bat Cave, 1(UIMNH), Dixon, 3(CMSU), Dixon, Piquet Cave, 11(10MHP, 1 UNMZ), Duke, 9(CMSU), Hunter's Cave, 1(UNMZ), Saltpetre Cave, 1(USNM/FWS), Wind Tunnel Cave, 1(MHP), 10 mi S Newburg, Ross Cave, 1(OSU), Waynesville, 8(CMSU), Waynesville, Bat Cave, 3(IISM, 1UNMZ, 1USNM/FWS), 6 mi SE Waynesville, 1(USNM/FWS), 5 mi S Waynesville, Maxey (Inca) Cave, 16(8CM, 7ISM, 1(SWMSU), 8 mi S Waynesville, Barry Cave, 1(UIMNH); Ripley Co.: Louis Cave, 1(UNMZ); St. Clair Co.: Monegaw Springs, Monegaw Cave, 3(2FMNH, 1UNMZ); St. Genevieve Co.: St. Genevieve, 2(UNMZ); St. Louis Co.: No specific locality, 1(CMSU), Eureka, 1(UNMZ); Tyson Research Area, 2(TBRC); Scott Co.: 1.5 mi SE Oran, 1(LSUMZ); Shannon Co.: No specific locality, 2(PSUMC), Alley Spring, 7(WJC), 3 mi SW Arroll, 1(UNMZ), 1.3 km N, 9.1 km W Eminence, Branson Cave, 1(UNMZ); Stone Co.: 2 mi S Kimberlin City, 6 mi E Hurley, 2(AMNH), Branson Cave, 1(MSUMZ), 4 mi S Reeds Spring, 2(UNMZ), 5.5 mi S Reeds Spring, 2(UIMNH), Rockwell's Cave, 1(UNMZ); Taney Co.: No specific locality, 3(2PSUMC, 1NMMZ), Branson, Marvel Cave, 5(3AMNH, 1OU, 1UNMZ), Paradise Estates Cave, 2(MSUMZ), Protom, 3(CMSU); Texas Co.: No specific locality, 2(WJC), Arroll, 1(UNMZ), 4 mi NW Bucyrus, 1(SWMSU), Chimney Rock Cave, 1(UNMZ), Licking, 1(WJC); Washington Co.: 5 mi W Potosi, 1(TSC), Wayne Co.: Mill Spring, 2(FMNH), 3 mi W Patterson, 4(ASUMZ), 3 mi W Patterson, Yancey's Cave, 1(UNMZ), 3 mi N, 10 mi E Piedmont, 1(MHP); Wright Co.: Mansfield, 1(UNMZ), 1.2 mi SE Mansfield, 10(6MHP, 4TTU), 1.5 mi SE Mansfield, 42(8TBRC, 34TCWC), 1 mi SE Mountain Grove, Taylor's Cave, 2(UNMZ), Norwood, 1(SWMSU).

Additional records: Barry Co.: Roaring River State Park (Easterla, 1968); Franklin Co.: Meramec Park Lake (LaVal et al., 1977); Pulaski Co.: Inca Cave (Myers, 1960).

Eptesicus fuscus, big brown bat (Map 13).

Specimens examined: (311). Missouri: No specific locality, 31(23CMSU, 8MCZ); Adair Co.: Connelville, 1(NEMSU), Kirksville, 16(2CM, 1FMNH,

13NEMSU), Campus NEMSU, 1(NEMSU); Barry Co.: Casper, Roaring River State Park, Bredford's Cave, 2(UNMZ), 1 mi N & 6 mi E Cassville, 3(SWMSU);



Map 13. Distribution of the big brown bat, *Eptesicus fuscus*

Benton Co.: No specific locality, 4(3ISM, 1NEMSU); Boone Co.: No specific locality, 4(WJC), 14 mi E Cape Fair, 1(SEMSU), 10.5 mi W Columbia, Rocheport Cave, 19(2CM, 2SWMSU, 15UNMZ), Columbia, 2(1UNMZ, 1WJC), Hunter's Cave, 11(UNMZ), University of Missouri Campus, 1(UNMZ), Easley, 2(WJC), Rocheport, Boone Cave, 3(NEMSU); Buchanan Co.: E St. Joseph, 1(UNMZ); Butler Co.: Silva, Hwy 67, 1(ASUMC), Keener's Cave, 2(UNMZ); Cape Girardeau Co.: No specific locality, 1(SEMSU), Cape Girardeau, 2(1ISM, 1LSUMZ); Carter Co.: Big Spring State Park, 1(USNM/FWS); Christian Co.: 4 mi N Ozark, 1(ISM), 10 mi S Springfield, James River Cave, 1(UNMZ); Clay Co.: Excelsior Spring, 2(CMSU); Cole Co.: Jefferson, 3(NEMSU); Crawford Co.: Boulder Cave, 2(1SEMSU, 1UNMZ), 6.3 mi SE Bourbon, 1(LSUMZ), Onyx Cave, 1(KU); Douglas Co.: 2.2 mi SW Evans, 19(5MHP, 1SUVM, 9TCWC, 4TSC); Franklin Co.: Meramec State Park, Mushroom Cave, 5(2KU, 3UNMZ); Greene Co.: 8 mi N Springfield, Crystal Cave, 1(KU), Springfield, 4(1PSUMC, 3SWMSU), 0.25 mi S Junction Sunshine & Pieison Creek, 1(ISM), Sequoia Park, 1(SWMSU), SWMSU Campus, 1(UNMZ), 8 mi S Springfield, 1(SWMSU); Grundy Co.: No specific locality, 3(MSU), 8 mi W Spickard, 1(KU), 7 mi W Spickard, 7(TCWC); Harrison Co.: 2 mi S Bethany, 1(KU); Howard Co.: Lisbon, 1(CMSU); Iron Co.: Pilot Knob, Pilot Knob Mine, 3(1TCWC, 2UNMZ); Jackson Co.: Independence, 1(MWSU), Kansas City, 4(1KU, 3MWSU); Jasper Co.: 0.5 mi N Sarcouxie, 1(PSUMC); Jefferson Co.: No specific locality, 2(TBRC); Johnson

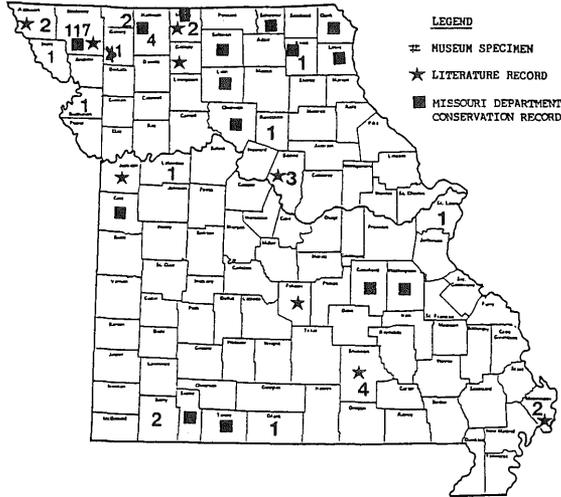
Co.: No specific locality, 1(ISM), Warrensburg, 10(CMSU); Knox Co.: Edina, St Joseph Church, 6(NEMSU); Laclede Co.: Eldridge, 1(CMSU), 2 mi S Hazelgreen, 1(OSU); Lawrence Co.: No specific locality, 1(SWMSU), Lime Kill Cave, 2(UNMZ); Lincoln Co.: Elsberry, 1(UNMZ); Macon Co.: South Gifford, 1(NEMSU); Madison Co.: 21 mi SW Fredericktown, 1(ASUMZ), 1 mi NE Saco, 4(ASUMZ), Saltpetre Cave, 3(1ASUMZ, 2UNMZ), Still House Cave, 3(ASUMZ); Marion Co.: No specific locality, 1(WJC); Miller Co.: 2 mi S, 0.5 mi W Iberia, 4(FMNH), Tuscumbia, 1(CMSU); Newton Co.: Joplin, 1(PSUMC), 1 mi S Joplin, 1(PSUMC); Nodaway Co.: 6 mi SE Maryville, 1(USNM/FWS), 4 mi SE Maryville, 3(1NWMSU, 2USNM/FWS), 6 mi S Maryville, 6(NWMSU), Maryville, 1(USNM/FWS); Oregon Co.: No specific locality, 1(CMSU), Thomasville, 1(UNMZ); Phelps Co.: Saltpetre Cave, 5(MHP); Pike Co.: Frankford, 2(SIUCM); Pulaski Co.: No specific locality, 1(WJC), 3 mi NE Big Piney, Miller's Cave, 1(FMNH), 4 mi S Crocker, Bill Williams's Bat Cave, 6(4CM, 1UIMNH, 1UIUC), 4 MI S Crocker, Wind Tunnel Cave, 4(2UIUC, 2UNIMH), Guano Cave, 1(MHP), 5 mi E Edgar Springs, 1(OSU), Richland, 1(CMSU), Waynesville, 1(CMSU); Ripley Co.: Louis' Cave, 1(UNMZ); St. Clair Co.: 3 mi E Monegaw, 1(KU); St. Louis Co.: No specific locality 1(TBRC), Overland, 4(MHP), Tyson Research Area, 12(TBRC); Shannon Co.: 0.5 km N, 7.0 km W Eminence, 10(UNMZ); Stone Co.: Marvel Cave, 9(2OU, 1SWMSU, 6UNMZ), Reeds Spring, Fairy Cave, 2(1AMNH, 1UNMZ); 4 mi N, 1 mi E Reeds Spring, Old Spanish Cave, 1(KU); Taney Co.: Branson, 1(UNMZ), Rockaway Beach, 1(KU); Texas Co.: No specific locality, 1(WJC), Arroll, 2(UNMZ); Washington Co.: Caledonia, 2(UNMZ); Wayne Co.: Coldwater General Baptist Church, 1(ASUMZ), Holmes' Cave, 3(1SIUCM, 2UNMZ), 2 mi E Patterson, 1(INHS); Wright Co.: 1.2 mi SE Mansfield, 2(1MHP, 1TCWC).

Additional records: Franklin Co.: Meramec Lake Park (LaVal, et al., 1977); Grundy Co.: 12 km W Spickard (Watkins and Shump Jr., 1981); Nodaway Co.: 4 mi SE Maryville (Easterla and Watkins, 1969); Pulaski Co.: Inca Cave (Myers, 1960).

Nycticeius humeralis, evening bat (Map 14).

Specimens examined: (147). Cushion Lake, 1(USNM/FWS), Atchison Co.: 4.5 mi NE Westboro, 1(NWMSU), 4 mi NE Westboro, 1(NWMSU); Barry Co.: Casper, Roaring River State Park, 1(UNMZ), 8 mi S, 5 mi E Cassville, 1(MHP); Boone Co.: Columbia, 3(UNMZ); Buchanan Co.: St. Joseph, 1(NWMSU); Gentry Co.: 11 mi NE Albany, 1(NWMSU); Harrison Co.: 2 mi S Bethany, 1(NWMSU), 2 mi S New Hampton, 1(NWMSU), 1 mi N Washington Center, 1(NWMSU), 4 mi E Washington Center, 1(NWMSU); Holt Co.: Mound City, 1(NWMSU); Knox Co.: 4 mi W Edina, 1(NEMSU); Lafayette Co.: Higginsville, 1(UMSL); Mercer Co.: No specific locality, 1(MSU), 1.5 mi NE

Modena, 1(NWMSU); Mississippi Co.: Big Oak Tree State Park, 2(NWMSU); Nodaway Co.: No specific locality, 2(UNMZ), 2 mi SE Arkoe, 1(NWMSU), 2 mi



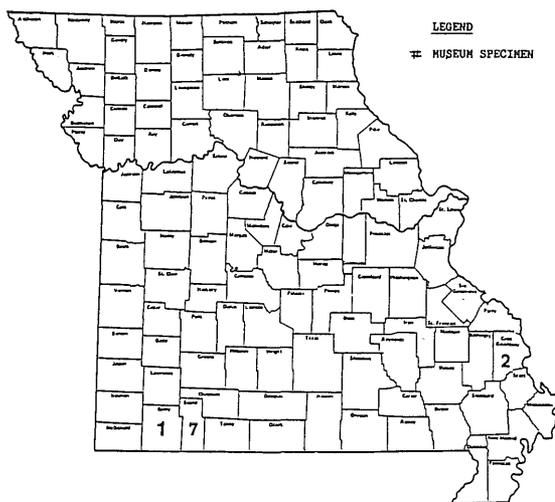
Map 14. Distribution of the evening bat, *Nycticeus humeralis*

NW Bolekow, 1(NWMSU), 2.5 mi NW Clearmont, 1(NWMSU), 4 mi SE Clearmont, 1(NWMSU), 1.5 mi SE Clearmont, 1(NWMSU), 5 mi NW Elmo, 1(NWMSU), 2 mi NE Elmo, 1(NWMSU), 1 mi NE Gaynor, 1(NWMSU), 7.5 mi NW Maryville, 1(NWMSU), 5 mi E Maryville, 1(NWMSU), 6 mi SE Maryville, 2(USNM/FWS), 4 mi SE Maryville, 3(NWMSU), within 6 mi Maryville, 83(NWMSU), 6 mi S Maryville, 14(NWMSU), 4 mi E Pickering, 1(NWMSU), 3 mi NW Sheridan, 1(NWMSU), 1.75 mi NW Sheridan, 1(NWMSU); Ozark Co.: 7 mi S Thornfield, 1(TSC); Randolph Co.: Moberly, 1(UNMZ); St. Louis Co.: Tyson Research Area, 1(TBRC); Shannon Co.: No specific locality, 4(NWMSU); Worth Co.: 5 mi NE Parnell, 1(NWMSU), 8 mi N Stanberry, 1(NWMSU).

Additional records. Atchison Co.: 1 mi S Blanchard, Iowa (Easterla, 1970); 7 mi NE Westboro (Watkins, 1970); Boone Co.: (Easterla, 1965); Gentry Co.: 8 mi N Stanberry (Watkins, 1970); Harrison Co.: 2 mi S New Hampton (Watkins, 1970); Jackson Co.: N Kansas City (Easterla, 1965); Nodaway Co.: 3 mi SE Arkoe (Watkins, 1970); 3.5 mi SE Clearmont (Watkins, 1969), 2.5 mi NE Elmo (Watkins, 1970), 6 mi SE Maryville (Easterla and Watkins, 1968), 1.75 mi NW Sheridan (Watkins, 1970); Pulaski Co.: Bat Cave (Easterla, 1965); Shannon Co.: (Easterla, 1965).

Plecotus rafinesquii, eastern big-eared bat (Map 15).

Specimens examined: (10). Barry Co.: Cassville, 1(UNMZ); Cape Girardeau Co.: 10 mi from Cape Girardeau, 1(UNMZ), Cape Girardeau, 1(UNMZ); Stone Co.: 0.5 mi W Fairy Cave, 2(ISM), Fairy Cave, 1(UNMZ), Powell's Cave, 2(UNMZ), Reed's Spring, Meade's Cave, 1(UNMZ), Reed's Spring, Sullivan's Cave, 1(UNMZ).



Map 15. Distribution of the eastern big-eared bat, *Plecotus rafinesquii*

Plecotus townsendii, western big-eared bat (Map 16).

Specimens examined: (3). Stone Co.: No specific locality, 1(AMNH), Galena, Dillon's Cave, 2(1UNMZ, 1 UMSL).

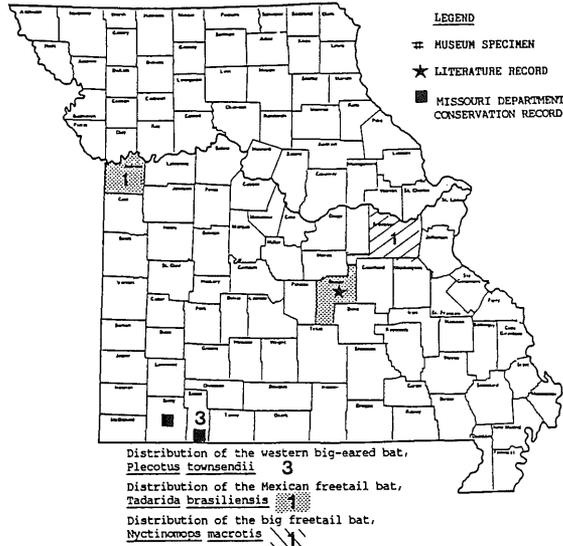
Tadarida brasiliensis, Mexican freetail bat (Map 16).

Specimen examined: (1). Jackson Co.: Nashua Area, 10 mi E State Line, 1(UNMZ).

Additional records. Phelps Co.: (Schwartz and Schwartz, 1981).

Nyctinomops macrotis, big freetail bat (Map 16).

Specimen examined: (1). Franklin Co.: 5.5 mi SW Pacific, 1(TBRC).



Map 16. Distribution of the western big-eared bat, *Plecotus townsendii*; the Mexican freetail bat, *Tadarida brasiliensis*, and the big freetail bat, *Nyctinomops macrotis*

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**PREDATION OF A BALD-FACED HORNET,
VESPULA MACULATA ON A
YELLOWJACKET, *VESPULA
MACULIFRONS***

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Vespinæ, social wasps are known to chew-up insects of various sorts to feed their young (Borror and White, 1970). Two members of *Vespinæ* includes yellowjackets, *Vespula maculifrons* and the bald-faced hornet, *V. maculata*. First generation *V. maculata* includes only female workers. They bring food several times a day to the larvae in their nest. The larvae feed on insects pre-chewed by the adult workers. The adults drink nectar, fruit juices and perhaps eat other insects (Milne and Milne, 1980).

On 10 August 1994 on Weldon Spring Military Training Area, St. Charles Co., Missouri, while preparing small mammal study skins, one of us (RMP) observed some adult *V. maculifrons* landing on the drying skulls hanging from a wire coat hanger, that was dangling from a tree branch. They continued to land and take off for over an hour. A *V. maculata* landed on the clump of skulls among several *V. maculifrons*. After a few minutes of surveying the skulls, the bald-faced hornet suddenly attacked one of the yellowjackets by repeatedly stinging it. In less than a minute the attack was over and the yellowjacket laid motionless. The bald-faced hornet grasped the paralyzed yellowjacket with its mandibles and flew off. This note represents the first reported predation by a *V. maculata* on a *V. maculifrons*.

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GENERAL CHEMISTRY STUDENTS' ATTITUDES TOWARD INTERACTIVE VIDEODISC LABORATORY EXERCISE

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Abstract: Too often science laboratory experiments follow a "cookbook" procedure which produces results to verify a fact students already have been told is true. On the other hand, experiments that challenge students to think and be actively involved by guiding them to discover evidence of concepts they have not already memorized will improve student attitude, motivation, and achievement. With this goal in mind, Northwest Missouri State University included interactive videodisc exercises as approximately one-third of the General Chemistry laboratory course. The main purpose of this study was to elicit students' attitudes toward the computer laboratory exercises in order to understand how they perceived these exercises in comparison to traditional wet laboratories. A 31 question survey was administered to 195 General Chemistry I students. This survey elicited demographics, general computer usage information, and students' attitudes towards various aspects of the computer hardware, the videodisc laboratories, the software, the work sheets, and the design of the course. The attitude questions were presented in the Likert format with a point scale from 1 point for agree strongly to 5 points for disagree strongly. Four conclusions can be drawn from the students' responses to the attitude questions. First, students found the computer laboratory and the videodisc experiments "user-friendly." Second, students think there are some learning advantages to using computers. Third, students believe the videodisc exercises accurately depict real experiments. Finally, students did not generally prefer either laboratory setting over the other.

Key Words: Chemistry laboratory, computers, interactive videodisc, student attitudes

Introduction

Too often laboratory experiments are simply verification exercises. Students follow a "cookbook" procedure designed to produce results which verify that a fact they already have been told is true. Not only is this not intellectually stimulating, it creates little enthusiasm in students. Rather, experiments that challenge students to think and be actively involved by guiding them to discover evidence of concepts they have not already memorized will improve student attitude, motivation, and achievement. With this goal in mind, Northwest Missouri State University integrated interactive videodisc exercises into General Chemistry laboratories in the Fall of 1994. These exercises comprised approximately one-third of the laboratory classes. The purpose of this study was to elicit students' attitudes toward the computer laboratory exercises in order to understand how they perceived these exercises in comparison to traditional wet laboratories. The study had three major goals. The first area was to assist in determining whether or not these computer exercises are an effective alternative setting to wet laboratories. Second was the evaluation of which laboratories students found most valuable.

And finally, it solicited student input for designing work sheets and planning future exercises.

Background

The technological developments that have resulted in interactive videodisc programs began with the use of videotapes of actual experiments. Students watched a videotape and then answered questions. But just watching a videotape did little to actively engage their minds. As computers came into use, they generated questions about still pictures. Students answered these questions and received immediate feedback regarding their conclusions. Although this arrangement was indeed highly interactive, still photos nevertheless lacked the realism of full-color motion pictures. The solution was to combine the two media to form interactive videodisc technology. The motion picture simulation is on a videodisc (or CD-ROM) and the computer supplies the interactive text, graphics, databases, and questions. The computer also controls the video sequences, supplying the appropriate frames as needed. It is now possible to load the software and CD-ROM data directly onto the hard drive of the computer, thereby dispensing with the videodisc player (Jones & Smith, 1989).

Due to its versatility, the computer has become an important classroom tool. Computers have several advantages, both pedagogical and practical, over traditional wet laboratory experiments. The interactive nature of videodisc programs requires students to be actively involved in their own learning processes. They cannot passively sit and listen to a lesson. The lessons are arranged and written so students practice hypothesis formulating, predicting, choosing variables, testing, analyzing, and drawing conclusions, rather than memorizing and regurgitating easy-to-forget facts. The result is improved scientific critical thinking and problem-solving skills (Cordes, 1990; Hoffer, Radke et al., 1992; Jones & Smith, 1989).

Because students control the work pace, lessons can be individualized. Students may work at a comfortable speed and may review material as often as necessary (Hounshell & Hill, 1989; Leonard, 1989; Smith & Jones, 1991). Moreover, there is the added flexibility of designing either individual or cooperative projects.

The videodisc adds visual images to text and numerical information. This makes the formal and abstract concepts more concrete. The visual stimulus also reinforces verbal learning (Cordes, 1990).

Students receive immediate feedback regarding their answers and conclusions. This not only includes grading their answers on standard drill exercises, but also includes prompting which can lead them along a path to a correct answer. This form of immediate feedback insures that students do not progress to more detailed information or more deeply into the experiment until they

have some degree of understanding of the foundation material (Cordes, 1990; Hounshell & Hill, 1989; Jones & Smith, 1989; Leonard, 1989).

The videodisc uses examples drawn from real-life situations to demonstrate concepts. This makes the textual material more familiar, realistic, and interesting to students. In wet laboratories, the particular experiment is controlled by feasibility factors and consequently the experiment may bear little relevance to students' everyday lives (Smith & Jones, 1991).

The interactive videodisc program can also be used as a pre-wet laboratory exercise. It can review and instruct in the concepts necessary to understand laboratory data, introduce and model the skills needed to perform the actual experiment, and provide students with typical experimental data in order to practice analysis techniques. Students thus have more confidence upon entering the wet laboratory and make fewer procedural mistakes (Cordes, 1990; Smith & Jones, 1991).

Interactive videodisc programs make more efficient use of time. Students do not have to wait for an experiment to develop, nor do they have to set up any apparatus or stand in line for chemicals (Cordes, 1990; Hoffer et al., 1992; Hounshell & Hill, 1989; Smith & Jones, 1991).

Moreover, the use of a videodisc makes it possible to utilize experiments not normally included in an introductory laboratory course. Worthwhile experiments are often rejected because they require explosive, toxic, or very expensive chemicals (Hoffer et al., 1992; Leonard, 1989; Smith & Jones, 1991). The videodisc obviously mitigates those barriers.

There are several studies which have compared the achievement scores of students learning in an interactive videodisc laboratory to those of students in traditional laboratories. These studies support the claim that students using interactive videodisc technology have higher achievement scores (Hounshell & Hill, 1989; Jones & Smith, 1989; Leonard, 1989).

Currently, one-third of Northwest Missouri State University's General Chemistry I laboratories are performed with interactive videodiscs. The computer laboratory contains 20 terminals with IBM 486-DX computers and seats 40 students. Since the CD-ROM is loaded on the hard drive there is essentially no wait for screens to change. The software is entitled *Exploring Chemistry IV; CD-ROM* by S. Smith and L. Jones and is distributed by Falcon Software, Inc. of Wentworth, NH. The topics currently covered using this software are: Chemical Reactions, Gas Laws, Solubility, Oxidation and Reduction, Electrons and Orbitals.

Method

For the purpose of determining student attitudes, this study utilized a thirty-one question survey, which was administered to 195 General Chemistry I students at the end of the Fall, 1994 semester. Figure 1 is a list of the questions and possible responses. Questions 1-3 requested demographic information. Questions 4-11 recorded current computer usage as well as a description of the students' comfort level using a computer. Questions 12-23 elicited students'

Figure 1. List of questions and possible responses to the student survey.

1. Class standing:
1 = Freshman 2 = Sophomroe 3 = Junior 4 = Senior
2. What grade do you expect to receive in laboratory?
1 = A 2 = B 3 = C 4 = D 5 = F
3. Gender: 1 = female 2 = male
4. Which answer best describes your use of computers this semester?
1 = 2-3 times a day 2 = 1 time a day 3 = 2-3 times a week
4 = 2-3 times a month 5 = virtually never

Questions 5-11 -- Answer 'YES' if you use the computer for each of the following activities and 'NO' if you do not.

- 1 = yes 2 = no
5. entertainment (games)
6. word processing
7. spread sheet
8. interactive programs
9. internet
10. other
11. Which answer best describes how comfortable you are using a computer?
1 = always very comfortable 2 = usually comfortable
3 = neither comfortable or uncomfortable -- neutral
4 = sometimes uncomfortable 5 = always very uncomfortable

Use the following scale for questions 12-23:

- 1 = agree strongly 2 = agree somewhat 3 = neutral 4 = disagree somewhat 5 = disagree strongly
12. I felt like I was participating in a real experiment.
13. It was easy to follow the steps through the videodisc program.
14. The videodisc pictures were realistic.
15. The computer machine was difficult to use.
16. The printed worksheet followed the program well.
17. The printed worksheet gave me a useful hard copy of the exercise.
18. I looked forward to going to the traditional laboratory more than computer laboratory
19. I liked being able to complete a laboratory exercise on my own time schedule.
20. After seeing equipment work on the computer, I think I could use the same equipment in a wet laboratory.
21. I believe I learned more from traditional laboratory than a computer laboratory.
22. The interactive prompting from the computer helped me to think through my answers and come up with the correct answer.
23. The visual images on the screen helped me learn the material better.

In questions 24-28, rate each videodisc exercise using the following scale:

- 1 = excellent 2 = good 3 = fair 4 = poor
24. Chemical Reactions
25. Solubility
26. Oxidation-Reduction
27. Gas Laws
28. Orbitals & Electrons
29. List the two things you liked best about the computer laboratory.
30. List the two things you liked least about the computer laboratory.
31. What one thing would you do to improve the computer laboratory?

attitudes towards various aspects of the computer hardware, the videodisc laboratories, the software, the worksheets, and the design of the course. These twelve questions were presented in the Likert format with a point scale of: 1 point for agree atrongly, 2 points for agree somewhat, 3 points for neutral, 4 points for disagree somewhat, and 5 points for disagree strongly. In questions 24-28 the students were asked to rate each of the specific videodisc laboratories from 1 for excellent to 4 for poor. The final three questions, 29-31, solicited subjective comments from students regarding what they most and least liked about the computer laboratories and what one thing would they do to improve the computer laboratories.

All student responses were compiled into frequency tables using the SAS statistical package. The responses for questions 1-11 and 24-28 are reported as a percentage for each category of response. In order to analyze the data generated by the Likert-style questions (12-23), a mean scale score for each question was calculated.

Results

Demographic and Computer Usage Questions

Of the 186 students responding to the survey, 46% were female and 54% were male. Freshmen comprised 38% of the class, 32% were sophomores, 21% were juniors, and 9% were seniors. For anticipated grade in the couree, 21.1% answered A, 49.2% answered B, 24.3% answered C, 4.9% answered D, and 0.5% answered F. In reporting recent amount of computer usage, 29.0% reported using the computer 2-3 times a day, 15.1% reported 1 time a day usage, 25.8% reported 2-3 times a week usage, 26.9% reported 2-3 times a month, and 3.2% reported using the computer virtually never. When indicating degree of comfort using a computer, 38% marked always comfortable, 57.0% marked usually comfortable, 15.6% marked neither comfortable or uncomfortable, 7.0% marked sometimes uncomfortable, and 9% marked always uncomfortable.

Attitude Questions

The number of students marking each Likert response and the mean scale score for each attitude question (12-23) is reported in Table 1.

Conclusions

Four conclusions can be drawn from the survey results. First, students found using the computer laboratory and the videodisc experiments "user-friendly." Second, students think there are some learning advantages to using computers. Third, students believe the videodisc exercises accurately depict real experiments. Finally, students did not generally prefer either laboratory setting over the other.

Table 1. Likert-style attitude questions, number of students making each response, and mean scale score.

QUESTIONS	NUMBER OF STUDENTS RESPONDING					MEAN & STD. DEV.
	1	2	3	4	5	
I felt like I was participating in a real experiment.	34	107	21	16	8	2.23 ± 0.99
It was easy to follow the steps through the videodisc program.	91	71	16	8	0	1.68 ± 0.81
The videodisc pictures were realistic.	107	68	10	1	0	1.49 ± 0.63
The computer machine was difficult to use.	5	20	23	64	74	3.98 ± 1.09
The printed worksheet followed the program well.	71	88	17	8	2	1.83 ± 0.85
The printed worksheet gave me a useful hard copy of the exercise.	65	90	21	8	2	1.88 ± 0.85
I looked forward to going to the traditional laboratory more than computer laboratory.	27	25	44	44	46	3.31 ± 1.36
I liked being able to complete a lab exercise on my own time schedule.	113	47	15	9	1	1.58 ± 0.88
After seeing equipment work on the computer, I think I could use the same equipment in a wet laboratory.	33	102	36	14	1	2.18 ± 0.83
I believe I learned more from traditional laboratory than a computer laboratory.	28	44	66	34	14	2.80 ± 1.13
The interactive prompting helped me to think through my answers and come up with the correct answer.	59	106	14	5	2	1.84 ± 0.76
The visual images on the screen helped me learn the material better.	73	83	26	3	1	1.80 ± 0.78

1 = agree strongly 2 = agree somewhat 3 = neutral 4 = disagree somewhat 5 = disagree strongly

The first conclusion, that the students found the computer laboratory and the videodisc experiments "user-friendly," is supported by three mean responses: "agree strongly" (1.69) to "easy to follow videodisc program steps," "disagree" (3.93) to "computer is difficult to use," and "agree" (1.83) to "worksheet followed program well." The implication of this conclusion is for the learning environment. If the computer is difficult to use, or if the software or accompanying worksheet is confusing, student enthusiasm for the computer laboratories would be eroded, regardless of whether or not the program was pedagogically sound.

Students consistently reported believing there were advantages to learning with a computer. This conclusion is supported by the following mean responses: "agree" (1.80) to "visual images helped learn better," "agree" (1.88) to "worksheet gave useful hard copy," "strongly agree" (1.57) to "like own time schedule," and "agree" (2.18) to "helps to learn how to use laboratory equipment."

Perhaps the most important piece of information initially hoped to be gained from this survey was whether or not students perceived the computerized laboratory exercises as "real" experiments. The Northwest Chemistry Department wished to insure that students felt they were engaged in a real experiment, not just watching a movie. The "agree" mean response (2.20) to "felt like a real experiment" and the "strongly agree" mean response (1.47) to "videodisc pictures were realistic" support the conclusion that students believe the interactive videodisc exercises do indeed simulate experimental conditions.

As applicable as the above is in supporting the use of computerized laboratory exercises, the final conclusion has perhaps the greatest implication for planning future utilization of interactive videodisc laboratory exercises. When asked whether they "look forward to traditional laboratory more than computer laboratory" and if they "learn more from traditional laboratory," the mean response in both instances was virtually neutral (3.34 and 2.81 respectively). Even though students found using computers easy, and realized the learning value of interactive videodisc exercises, they did not prefer one laboratory setting over the other. One possible explanation for this result is that students realize that no matter how flexible and useful a learning tool the computer is, there are things it cannot do, particularly develop hands-on skills that can only be learned by using them in a traditional laboratory.

Based on the results of this questionnaire, in addition to faculty satisfaction with the videodisc exercises, Northwest plans to continue its current method of utilizing interactive videodisc laboratory exercises in general chemistry laboratories.

Future Questions

There remains ground for fertile debate over the role of interactive videodisc exercises in the designing of laboratory experiences for general education classes as opposed to science major classes. Science majors must gain proficiency

in basic laboratory techniques in order to be prepared for more advanced laboratory work and this is one of the main objectives of a general chemistry laboratory class. However, general education students rarely spend enough time in laboratory to gain any measure of proficiency and do not require those skills as a foundation for future work. They do, however, gain important critical thinking skills in predicting, planning, and analyzing data, abilities with direct application to disciplines other than science. In light of the pedagogical and practical advantages of computer laboratories, one could argue that general education students would gain more from experimental simulations which will always yield good data with which to work. Questions of this nature must be addressed by science faculties as higher levels of technology become more widely available and we continue to explore how to educate our population. The most effective approach for one group may not be appropriate, or even desirable, for another.

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**PREDATION ON THE HOUSE WREN,
TROGLODYTES AEDON, BY THE EASTERN GRAY
SQUIRREL, *SCIURUS CAROLINENSIS***

(Received July, 1966; accepted for publication August, 1996)

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The diet of the eastern gray squirrel, *Sciurus carolinensis*, is varied. Of the 100 or so different species of plants that are known to provide food for eastern gray squirrels, the staples are hickory, pecan, oak, walnut, elm, and mulberry trees plus field corn (Schwartz and Schwartz, 1981). In addition to nuts, seeds, and fruits, typical foods include fungi, buds, stems, flowers, and insect larvae (Schmidly, 1983; Caire et al., 1989; Hoffmeister, 1989; and Sealander and Heidt, 1990). Eastern gray squirrels may supplement their diet by chewing on bones and antlers, which supply needed calcium, or on turtle shells (Schwartz and Schwartz, 1981; Schmidly, 1983). Additionally, numerous authors (e.g., Choate et al., 1994) have noted that eastern gray squirrels may eat bird eggs and young birds.

At 1430 h on 6 August 1994 at a place 5 km E Murray, Callaway County, Kentucky, one of us (VLF) watched as an adult eastern gray squirrel climbed down a shagbark hickory and up a crimson red maple approximately 15 m away. There, it snatched a juvenile house wren, *Troglodytes aedon*, out its nest and carried it to the base of the tree and began eating. While it was eating the young bird, two adult house wrens circled overhead giving alarm cries and diving at the squirrel. Finally, the squirrel, with bird in mouth, ran up the hickory tree from which it had launched its attack. After about six minutes, the squirrel was seen sitting on a branch approximately 20 m above the ground grooming itself. A search of the area revealed only a few feathers at the base of the crimson red maple tree and a few under the shagbark hickory tree. This observation suggests that eastern gray squirrels not only consume juvenile birds found inadvertently when foraging, but also that they visually pinpoint the locations of occupied nests for the purpose of subsequently feeding on young birds.

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CHARACTERISTICS OF PRODUCERS AND CONSUMERS AT NORTHWEST MISSOURI FARMERS' MARKETS

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Abstract: A survey was conducted to determine the characteristics of the producers and consumers that frequent northwest Missouri farmers' markets. Producers were asked about their growing and marketing operations. The typical producer is part time (43%) and retired (52%). Of those surveyed, 76% derive less than 25% of their income from these operations. Most (80%) use five or fewer acres for production. Many (63%) employ at least a part-time worker. Over half (51%) travel 14 or more miles to sell at farmers' markets. Consumers were asked why they frequent farmers' markets, how much they buy and prices of produce. Consumers attend primarily for the quality and variety of produce (100% and 88% respectively) found at these markets as well as convenience. Most consumers (57%) were interested in traditional produce and about 7% were looking for novelty items. About 36% of the consumers believe farmers' market prices are the same or higher than grocery store prices and most (94%) are willing to pay higher prices for home grown produce. Two thirds of the consumers consider it important to have organically grown or pesticide free produce available.

Key words: markets, consumers, producers, prices, produce

Introduction

The Alternative Crops Program of the Department of Agriculture at Northwest Missouri State University serves the region by identifying and studying non-traditional crops that may be grown to enhance farm income and resource use. Traditionally, land in the region has been devoted to corn, soybeans, and livestock production. Expectations are that agriculture in the area will be dominated by the traditional farm enterprises. However, there is increasing interest by area growers in pursuing alternatives such as fresh market fruit and vegetables.

The process of investigating non-traditional crops has several aspects. One is determining the agronomic and economic suitability of crops to the soils and climate of the region. Another is identification and specification of the market for crops that may be produced. In some cases, markets for produce will have to be developed. Agronomic, economic, and market research are relevant activities for the alternative crops program.

A search for similar studies yielded two that targeted consumers at farmers' markets (Rathbun et al. 1987; Benson and Hobbs 1985). These studies were focused on consumer preferences and attitudes at primarily urban farmers' markets. The market for fresh produce has been segmented into three basic categories; (1) wholesale distributors which might be found in larger commercial centers, (2) direct sale to local grocers or other retail dealers in fresh produce, or

(3) direct retail sales to consumers either in roadside stands or at farmers' markets. Most producers in northwest Missouri produce a relatively small volume of produce. Production of large quantities is unlikely because of scarce labor resources in the region. Those that produce smaller volumes are assumed to market most of their produce through local farmers' markets.

Though it is appropriate to study the demand side of the market for various kinds of produce it is also important in this case to study the supply or producer side of any potential market. In reality it is a process to identify who the audience may be for the research results of the alternative crops program. The purpose of this project was to identify the characteristics of some potential producers and consumers that could benefit from alternative crops research results.

Methods

Separate survey instruments were developed for producers and consumers. The survey for producers was designed to identify the characteristics of producers. The consumer survey was constructed in such a way that the results could be used by producers and the university to aid in planning research. The surveys were completed in person at farmers' markets in 12 locations in northwest Missouri and southwest Iowa. Sites were identified using published directories of farmers' markets (Missouri Department of Agriculture 1992, Iowa Department of Agriculture 1991).

The survey was used to query 51 producers in the region. The producer survey requested information on employment status, whether or not their farming activities were full time, part time or hobby type activities. The producers were asked about the proportion of their income which came from sales at farmers' markets. Producers were also asked about their marketing activities, that is how much of their total production was sold at farmers' markets and how much was sold elsewhere. They were questioned about how many acres were devoted to production of consumer produce and how many different kinds of produce or fruit crops were cultivated. Each producer was asked about how much experience they had at farmers' markets, markets they frequent, miles they travel to markets, whether or not they market to grocery stores or at roadside stands and workers they employ.

The consumer portion of the study targeted individuals from the rural region of northwest Missouri that patronize farmers' markets. The survey instrument was administered to 33 consumers that attended the farmers' markets that were visited during the study. A larger sample of consumers is desirable, but this sample provides a reasonable cross section of consumers that attend farmers' markets. The information requested of targeted consumers at farmers' markets included the reasons why they shop at farmers' markets. They were also asked questions relative to produce quality and variety, how often they shop at farmers'

markets and how much of their produce they purchase at farmers' markets. Patrons were asked about their perception of price differences at farmers' markets relative to grocery stores, their willingness to buy locally grown produce in the grocery store and whether or not they would be willing to pay a premium price for locally grown produce.

Survey Results

Producers

Of those surveyed only 3.9 percent were full-time producers of crops marketed at farmers' markets (Table 1.). The remaining were part time producers. Almost 53 percent of the producers were retired growers participating as a hobby and to supplement income.

Table 1. Characteristics of producers attending farmer markets in northwest Missouri.

Characteristic	Percent
Employment Status	
Full time grower	3.9
Part time grower	43.1
Retired grower	52.9
Percentage of gross income from farmer markets	
< 25%	76.5
25 to 50%	13.7
50 to 75%	3.9
> 75%	5.9
Acreage of crops produced	
< 1 acre	31.4
1 to 5 acres	49.0
5 to 25 acres	17.6
> 25 acres	2.0
Production sold at farmer markets	
< 25%	17.6
25 to 50%	23.5
50 to 75%	29.4
> 75%	29.4
Workers employed (including producer)	
one	37.3
two	51.0
more than two	11.7

Only about 10 percent of the producers derive as much as half of their gross income from sales at farmers markets. In fact, more than 75 percent of the producers received less than 25 percent of their gross income from sales at farmers markets. This is expected because most of the producers are part-timers.

The income that the producers are able to generate is a function of the amount of product they produce and the price they receive. Table 1 depicts the distribution of producers by the number of acres they use to produce crops. About 80 percent of the producers farmed 5 or fewer acres, due primarily to the part time status of most of the producers. While 20 percent of the producers farmed 5 acres or more, only 2 percent (1 producer) farmed more than 25 acres.

Expectations were that at least some producers would market their produce at multiple outlets including farmers' markets. The producers that were surveyed indicated that about 70 percent sell less than 75 percent of their product at farmers' markets. Only about 30 percent sell more than 75 percent of their product at farmers' markets. The results were a bit of a surprise, otherwise questions would have been asked about other market outlets that were used by producers.

The number of acres or the variety of product that may be produced by those that attend farmers' markets are not always a good indicator of the "size" of an operation. To improve understanding of the size or intensity of operations questions were asked about the number of workers involved in the production of vegetable and fruit crops. Answers to questions about how many workers were involved in their operation were consistent with the answers to other questions in the survey. About 38 percent of the operations employed one person, the producer (Table 1). Almost 63 percent of the operations employed at least one worker besides the producer. Just under 12 percent of the operations employed more than two workers in addition to the producer. These employment results are in concert with the typical part time nature of the producers that were questioned in this survey.

Consumers

Why consumers shop at farmers' markets was of major interest. The quality of the products found at farmers' markets was the most important reason consumers attend (Table 2). The second most important reason consumers attend was convenience followed closely by the variety of products found at these markets. Although they were important, price and recreation were not major considerations for consumers when deciding to frequent the farmers' market. Only 6 percent of the consumers indicated that something other than the specified reasons for attending was important to them.

The quality of the products found at farmers' markets was expected to be an issue. Consequently consumers were asked to respond to a number of questions

related to quality. Of the consumers surveyed, the number one quality desired was freshness followed closely by the taste of the products (Table 2). Color is a factor that produce buyers would use to judge the quality of a product and in this survey

Table 2. Characteristics and expectations of consumers at northwest Missouri farmer markets

Items	Very Important	Important	Not Important
Reasons for attending			
Price	30%	52%	18%
Quality	97%	3%	0%
Convenience	70%	21%	9%
Recreation	21%	45%	34%
Variety	67%	21%	12%
Other	6%	0%	94%
Produce quality aspects			
Freshness	91%	3%	6%
Organically Grown	55%	27%	18%
Pesticide Free	55%	18%	27%
Color	64%	21%	15%
Taste	82%	3%	15%
Product expectations			
Vegetables	91%	6%	3%
Melons	58%	30%	12%
Fruit	67%	27%	6%
Berries	48%	36%	16%
Novelty	24%	27%	48%
Other	6%	3%	91%
Frequency of attendance		Percent	
Weekly		78%	
Monthly		16%	
Seasonally		6%	

Number surveyed - 33

was the third ranking quality aspect of the consumers. Consumers were asked about their attitude concerning the use of chemicals for fruit and vegetable production. Those that responded indicated some concern, but did not seem to place as much importance on pesticide-free or organically-grown produce as might be expected. One-fifth of those surveyed indicated that whether or not produce was grown organically was of no importance. Over one-fourth of the consumers indicated that access to pesticide-free produce was not important.

The variety of products available at farmers' markets was one aspect that consumers desired. Part of this survey was to try and determine the scope of the varietal desires of consumers at farmers' markets. According to this survey, vegetables were the most important product that consumers expect to find at farmers' markets (Table 2). Fruit, melons and berries ranked second, third and fourth respectively in importance. Over one-half of the consumers (52%) indicated that it was important to them to find novelty products at farmers' markets. Only 9 percent responded that things others than those in the survey list were sought after at the markets.

Consumers that attend farmers' markets appear to consist of regular customers. The consumers that were surveyed in this study were mostly frequent attendees with 94 percent of them attending at least monthly and 78 percent attending on a weekly basis (Table 2). The remaining 6 percent only attend a few times per season.

Consumers were asked to relate their perceptions of prices at farmers' markets compared to grocery store prices. One-third of the consumers didn't know if a price difference existed and 18 percent thought the prices were the same (Table 3). About one-third of the consumers thought farmers' market prices were lower and half of those believed them to be more than 5 percent lower. Only 18 percent of the consumers believed the farmers' market prices to be higher than the grocery store prices and 3 percent of all consumers sampled thought the prices were more than 5 percent higher at farmers' markets.

A point of interest of this study was consumer willingness to buy home grown produce in grocery stores and whether or not they would be willing to pay a premium price for home grown produce. Of the consumers asked about buying home grown produce in grocery stores, 94 percent indicated they would, 3 percent said they would not and 3 percent said they didn't know (Table 3).

Consumer willingness to pay a premium price for home grown produce was mixed with some inclination toward paying a small premium. The largest proportion (67 percent) of consumers said they would pay a 5 to 10 percent premium. Of those willing to pay a higher premium, 15 percent would pay 10 to 15 percent more, 6 percent would pay as much as 15 to 20 percent more, and 6 percent would pay more than 25 percent more. Only 6 percent said they would not be willing to pay a premium price for home grown produce.

Reliance by consumers on farmers' markets for fresh produce was mixed for those surveyed. About 30 percent indicated that they purchase 20 percent or more of their produce from farmers' markets (Table 3). About 27 percent of the consumers buy between 10 and 20 percent of their produce at farmers' markets and 39 percent buy 5 to 10 percent. Only 3 percent said they didn't know how much of their produce was obtained at farmers' markets.

Table 3. Consumer perception of price differences and willingness to pay premiums.

Item	Percent
Prices at farmer markets compared to stores	
< 5% Lower	15
> 5% Lower	15
< 5% Higher	15
> 5% Higher	3
Same	18
Don't Know	33
Willingness to buy home grown produce in grocery	
Yes	94
No	3
Don't Know	3
Willingness to pay premium for home grown produce	
None	6
5-10%	67
10-15%	15
15-20%	6
20-25%	0
> 25%	6
Proportion of produce bought at farmer market	
None	0
5-10%	39
10-15%	15
15-20%	12
20-25%	12
> 25%	18
Don't Know	3

Summary and Implications

A survey was used to determine several characteristics of 51 producers in northwest Missouri that use farmers' markets as a marketing outlet. Another survey was used to question 33 consumers that frequent farmers' markets in the same region. Overwhelmingly, the results indicate that the majority of producers that attend are part time producers and a large proportion are retired. Most producers derive a small proportion of their income from these markets leading one to believe that they are hobby producers. Most of the consumers surveyed were loyal attendees mainly interested in good quality vegetables and fruit at reasonable prices.

The objective of this study was to determine the characteristics of producers and consumers in the region to provide some direction to alternative crops research. The results however indicate that those surveyed would constitute a major audience for research results. Primarily the program can serve as a resource to help producers provide a good quality product to the consumers of fresh produce in the region. Perhaps there is an opportunity to help expand production and marketing of good quality fresh produce to the region through farmers' markets as well as other marketing outlets on a seasonal basis.

Acknowledgments

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EFFECTS OF NITROGEN SOURCE AND POTASSIUM ON DRY SEEDED RICE

(Received October, 1995; accepted for publication October, 1996)

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Abstract: Rice (*Oryza sativa* L.) is a major crop in southeast Missouri and its profitability is largely dependent upon a high yield attainment, due in part to heavy fertilization with nitrogen fertilizers. This study was conducted to determine the relative efficiency of urea and ammonium sulfate as nitrogen fertilizers. Additionally, this study focused on the interaction between potassium fertilization and nitrogen source efficiency. A dry-seeded rice field experiment was conducted for two years by establishing a replicated block design consisting of two rates each of two pre-flood nitrogen sources crossed with a potassium source. Pre-flood nitrogen effectively promoted panicle formation; however, spikelet formation was not significantly promoted. During the 1994 season, urea proved to be superior to ammonium sulfate as a nitrogen source; however, during the 1995 season, both sources were equally effective in promoting yield. Nitrogen promoted vegetative development, causing potassium deficiencies because of tissue dilution. Major yield increases are likely if growers adopt a proper potassium and phosphorus fertility program. Additionally, yield differences because of nitrogen source were not sustained during the duration of this two year study.

Key Words: Nitrogen, potassium, rice, panicle development.

Introduction

Agronomists frequently partition yield into yield components. For rice (*Oryza sativa* L.) the commonly recognized yield components are:

$$\text{yield} = (\text{panicles/m}^2)(\text{spikelets/panicle})(\text{hull size}) \quad 1$$

Murata (1969) stated that yield formation in rice is a complex interplay of 1) the formation of organs for nutrient absorption (roots) and photosynthesis (leaves), 2) the formation of floral organs and the yield container (spikelets), and 3) the production, accumulation and translocation of yield contents (sugar). Citing contemporary research, Murata showed that the number of panicles/m² was determined approximately 10 days after maximum tiller stage. Similarly, the number of spikelets/panicle and hull size were determined approximately 10 days before flowering and spikelet numbers correlated with the nitrogen content of leaf blades approximately 1 to 4 weeks before flowering. Thus, nitrogen is important in promoting yield by its effect on tillering and the leaf area index (LAI), as well as its effect on panicle development. Chandler (1969) observed that hull size was the only yield component not significantly affected by nitrogen.

Murata (1969) commented on the effects of the timing of the nitrogen application. The effects of early nitrogen applications were to promote leaf expansion and vegetative development. Midseason applications essentially

promoted the net assimilation rate (photosynthesis). Thus the effect of the mid-season application is to increase carbohydrate accumulation at heading and at maturity. If nitrogen applications are late, then protein synthesis will interfere with carbohydrate synthesis and the grain yields will be reduced.

DeDatta (1987) observed that broadcasted urea applied in a split design with 2/3 applied at pre-flood and 1/3 at panicle initiation showed a 40% nitrogen recovery. Urea applied in water showed significant nitrogen losses (~20%) because of ammonia volatilization. Humphreys et al. (1987) investigated several methods of nitrogen application, noting that topdressing onto dry soil before permanent flooding is highly efficient for the rice growing regions of the central United States. Intermittent flooding had the effect of increasing nitrogen losses, presumably through the nitrification-denitrification process.

Reddy and Patrick (1978) showed that nitrogen applied to dry seeded rice prior to permanent flooding showed an excellent 51% nitrogen recovery. Similarly, the IAEA (1978) showed similar nitrogen recoveries if the nitrogen rates were between 25 and 100 kg N/acre (20-90 lbs N/acre). Wells et al. (1992) used leaf area measurements and SPAD meter readings to predict mid-season nitrogen application rates. Tisdale et al. (1985) have reviewed the nitrogen cycle and its reaction pathways.

A major problem in rice production in southeast Missouri is that potassium and phosphorus fertilization is performed only during the establishment of the rotation crop. As more growers attempt two or more years of consecutive rice cropping, the specter of phosphorus and potassium deficiencies increase. The purpose of this investigation was to determine: (1) if nitrogen source (urea vs ammonium sulfate) affected dry-land rice yields, and (2) if potassium fertilization influenced the efficiency of nitrogen fertilization.

Materials and Methods.

The rice research project was performed at the Missouri Rice Research Farm in Dunklin County, Missouri, during the 1994 and 1995 growing seasons. The soil series was classified as a somewhat poorly drained, very slowly permeable Crowley silt loam (Fine, montmorillonitic, thermic Typic Albaqualfs).

The experimental design consisted of a randomized complete block with 2 treatments involving: nitrogen source and potassium. The two nitrogen sources were urea (45-0-0) and ammonium sulfate (21-0-0). The 4x replicated plot treatments included: control, control with potassium, urea, urea with potassium, ammonium sulfate, and ammonium sulfate with potassium. Each plot was 3.05m x 6.10m (10 ft x 20 ft) with 0.60m (2 ft) alleys between adjacent blocks.

Nitrogen was applied pre-flood as either urea or ammonium sulfate at 134 kg N/ha (120 lbs N/acre) and potash (0-0-60) was applied pre-flood at 50 kg

K_2O /ha (45 lbs K_2O /acre). Two mid-season urea applications were applied at 34 kg N/ha (30 lbs N/acre) to all plots.

Lemont rice was seeded during mid-May and subsequently treated with a conventional Stam-Facet herbicide treatment. Plots were staked after stand assurance. Nitrogen and potassium fertilization was applied on mid-June, with the establishment of a permanent flood on the following day. Harvest occurred on 30 September (both years), using a plot combine (Courtesy of the University-Missouri Delta Center).

Tiller counts were performed several weeks after establishment of permanent flood. Other field measurements (plant height, color index, and chlorophyll meter readings (SPAD)) were taken 2 weeks after the 2nd mid-season nitrogen application. The color index was a simple visual rating of leaf blade color. Post harvest measurements included seed weight (g/100 seeds), average panicle seed number, and yield (Mg/ha). Approximately 15 plants were selected to determine the average panicle seed number. Field data were statistically analyzed by analysis of variance and Duncan's multiple range test (5%).

Results

Measurements taken after the second mid-season nitrogen application provide support for the premise that pre-flood nitrogen promoted tillering and plant height and marginally diminished spikelet development. During the 1994 season, the urea+K treatment exhibited the tallest plant height and all nitrogen treatments were significantly taller than the control (Figure 1). All nitrogen treatments

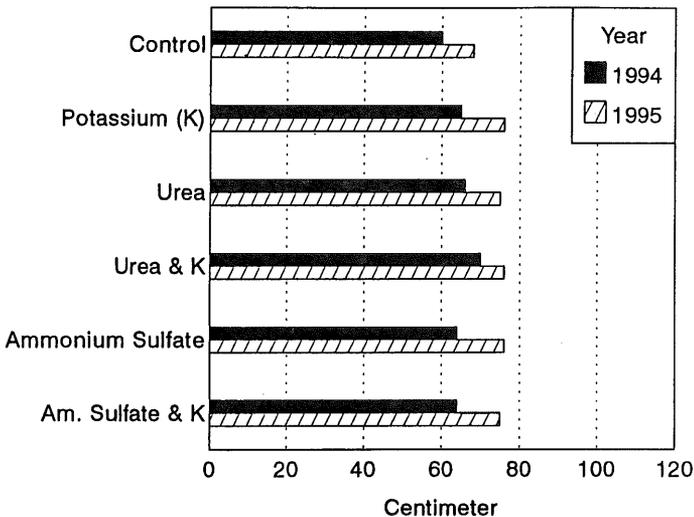


Figure 1. Effect of nitrogen and potassium treatments on rice height.

significantly promoted plant height with respect to the control during the 1995 season, but were not significantly different within nitrogen treatments. Thus, pre-flood nitrogen was statistically effective in promoting plant height, but not significant with respect to nitrogen source.

All nitrogen and potassium treatments during the 1994 season showed statistically greater tiller numbers than the control, while all nitrogen treatments during the 1995 season showed statistically greater tiller numbers with respect to the control and the potassium treatment (Figure 2).

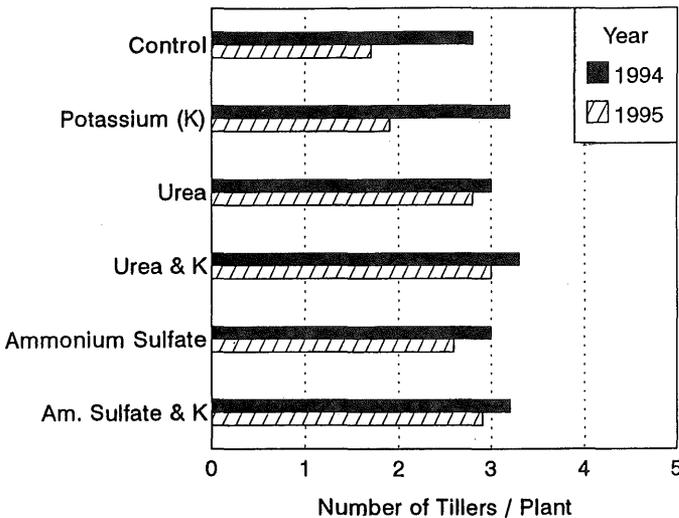


Figure 2. Effect of nitrogen and potassium treatments on rice tillering.

Prior to the mid-season nitrogen applications, pre-flood nitrogen treatments were statistically effective in promoting chlorophyll development as revealed by SPAD readings and in reducing the appearance of chlorosis as revealed by visual ratings (Data not shown). SPAD readings taken approximately two weeks after the mid-season nitrogen applications were not significant.

Panicle development is significantly affected by the nitrogen treatments (Figure 3). During the 1994 season the control and control+K treatments possessed significantly greater seed numbers within the panicle. Soil testing showed the soil to be extremely low in potassium. The greater vegetative growth because of nitrogen fertilization likely caused a potassium deficiency because of tissue dilution. Across all nitrogen treatments, urea treatments and the ammonium sulfate+K treatment exhibited greater seed numbers than the ammonium sulfate treatment. During the 1995 season the control exhibited significantly fewer seed

numbers than all other treatments. The nitrogen treatments were not significantly different. Seed weights were not significantly different across all treatments.

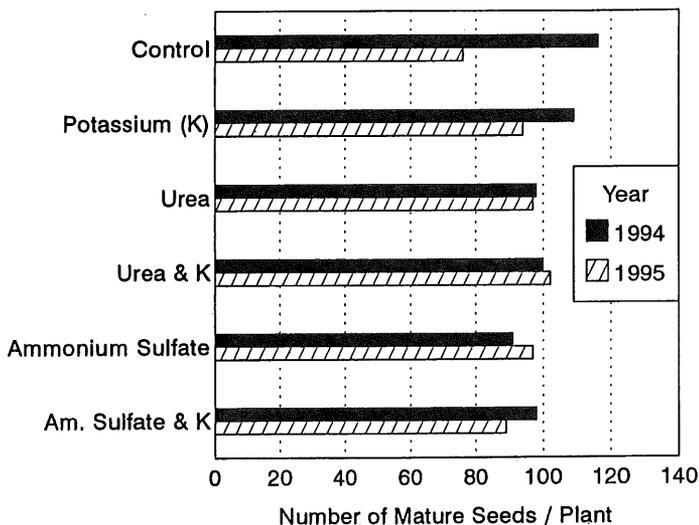


Figure 3. Effect of nitrogen and potassium treatments on rice panicle development.

Nitrogen treatments were effective in promoting yields during both years of the test (Figure 4). The urea+K treatment was significantly higher yielding than the ammonium sulfate+K treatment during the 1994 season; however, yields arising from nitrogen treatments were not significantly different during the 1995 season.

Discussion

Yield advantages because of pre-flood nitrogen fertilization appear to be the result of increased tillering capacity. During the 1994 season, nitrogen treatments significantly reduced the number of seed per panicle, while nitrogen treatments promoted panicle seed number during the 1995 season. Seed weights were not affected by the nitrogen treatments. Thus, nitrogen greatly promoted the number of panicles/m² and either did not influence or slightly reduced panicle seed numbers; thus resulting in a yield advantage.

Using the yield components (Equation 1), the effect of pre-flood nitrogen was to effectively increase tillering and panicle numbers. The effects of the mid-season nitrogen applications were to promote (1) panicle spikelet numbers and (2) photosynthesis. The yield advantage because of nitrogen rests with its effect on promoting tillering. Differences in nitrogen source were evident only during the 1994 season.

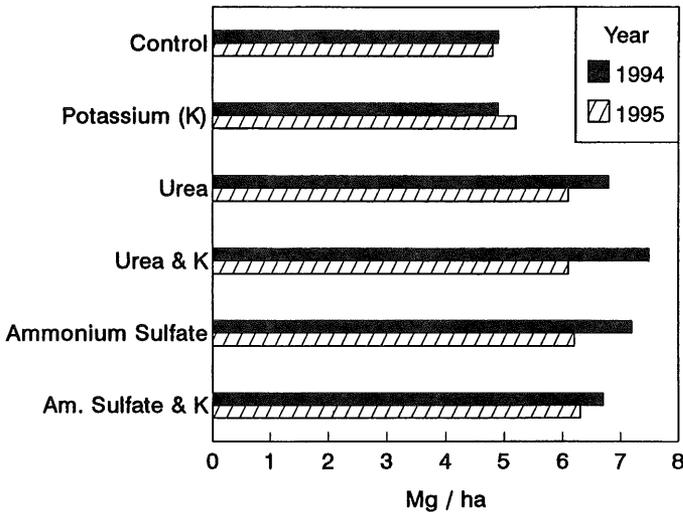


Figure 4. Effect of nitrogen sources and potassium on yield.

Acknowledgements

I wish to thank the University Missouri-Columbia - Delta Center for their assistance in the performance of this project and grant support from the Missouri Rice Research and Merchandising Council.

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ABSTRACTS

Physics abstracts from 1995 Annual Meeting

**Senior and Collegiate Division Abstract for the 1996
Annual Meeting**

NOTICE: The abstracts for the Physics Section of the 1995 Annual Meeting of the Missouri Academy of Science were accidentally left out of Volume 29, 1995, of the Transactions of the Missouri Academy of Science. The Editor apologizes for the omission and has included those abstracts in this volume of the Transactions.

**Ollin J. Drennan
Editor, Transactions**

Agriculture/Entomology/Herpetology Section

Bufalino, Angelo, Austin Peay State University, and David A. Easterla, Northwest Missouri State University. A PRELIMINARY ECOLOGICAL INVESTIGATION OF THREE GREAT PLAINS ANURAN SPECIES IN HOLT COUNTY, MISSOURI. The Great Plains Narrowmouth Toad (*Gastrophryne olivacea*), the Plains Spadefoot (*Scaphiopus bombifrons*), and the Great Plains Toad (*Bufo cognatus*) reach the periphery of their ranges in northwest Missouri (Holt County). Little is known about the ecology of these three anurans in Missouri and this preliminary study investigates their habitat requirements, breeding behavior, and population characteristics. From the spring of 1992 to the fall of 1993, 11 *G. olivacea* were observed from the southwest facing slopes of the loess hills to the Missouri River floodplain. Based on these observations and the available literature, *G. olivacea* occurs permanently from the Holt County loess hills, where suitable rocky habitat occurs, westward throughout the Missouri River floodplain to the river itself. Fifteen to 20 *S. bombifrons* were seen calling from a pool just west of Big Lake State Park during May 1993 and a breeding congregation of several hundred was encountered during June 1993 in the flooded fields east of Bob Brown State Wildlife Area. *Scaphiopus bombifrons* prefers prairie and floodplain habitats and undoubtedly occurs throughout the floodplain region of Holt County. A single *B. cognatus* was heard calling during May 1993 from a pool just west of Big Lake State Park and a few were calling from flooded fields east of Bob Brown State Wildlife Area during June 1993. This river floodplain species evidently occurs in localized breeding populations on the Missouri river floodplain of Holt County.

Physics Section

R. A. Anderson. Department of Physics, University of Missouri-Rolla. AN ADAPTIVE OPTICAL TELESCOPE. This paper describes a 1 m adaptive optical telescope developed through SDI funding. This telescope was designed as a prototype for a telescope as large as 10 m which would be used for power beaming. It was turned over to Marshall Space Flight Center for testing and operated to expectations in light of known design errors. A design of this type will be required to construct future astronomical telescopes due to weight and mounting problems for telescopes of 10 m diameter. The individual segments of this telescope will be small and light for they will be designed and constructed using integrated circuit techniques. This telescope will also be able to correct for atmospheric turbulence by sampling signals from "guide stars" and thus it is an adaptive optical system.

Jargoeki, C. Department of Physics, Central Missouri State University. DERIVATION OF QUARK MASS SPECTRA FROM THE FINITE ROTATIONAL SUBGROUPS OF $SU(2)_L \times U(1)_Y$. Despite its great success, the minimal Standard Model, based on the direct product gauge group $SU(3)_C \times SU(2)_L \times U(1)_Y$, is at the very least incomplete. Its 19 free parameters (for massless neutrino and no leptonic mixing angles), the origins of the family replication and of color symmetry, etc. remain to be elucidated. F. Potter's proposal provides a geometrical basis for the Standard Model: lepton and quark weak isospin families are assigned to the finite rotational subgroups of the electroweak gauge group $SU(2)_L \times U(1)_Y$. The masses of the up and strange quarks predicted using Potter's model are, unfortunately, somewhat at variance with the values normally used. The paper discusses possible ways of remedying the problem by focusing on the origin of quark mixing, and its consequences for the Kobayashi-Maskawa matrix and the quark mass values.

Kapoor, Yogendra. Department of Natural Sciences and Mathematics, Lincoln University. STUDY OF SMALL-ANGLE X-RAY SCATTERING IN SILICA XEROGELS. Small-angle x-ray scattering has been used to study xerogels prepared by polymerization of tetramethyl and tetraethyl orthosilicates. The scattering curves were consistent with the hypothesis that the gels were aggregates of primary particles that have diameters of several tens of Angstroms. A detailed analysis of the scattering curves showed that the data are in good agreement with the scattered intensity expected from aggregates of primary particles.

Lindevald, I.M. Division of Science (Physics), Northeast Missouri State University PROPAGATION OF SOUND AT JUNCTIONS IN HORNS. The propagation of one-dimensional sound waves in a horn with discontinuous taper is examined. The Horn Equation, which describes sound propagation in horns of varying cross section is akin to the Schroedinger Equation of quantum mechanics. The horn's geometry is represented by the horn function, $U(z)$, which replaces the quantum mechanical potential, $V(x)$. At a junction in a horn, $U(z)$ is infinite. It will be shown that the behavior of a sound wave at a junction can be characterized by including an extra inertance term in the wave impedance, and the prospects for using WKB-like approximation methods to achieve a solution will be explored.

Probst, David K. Department of Physics, Southeast Missouri State University and **Michael A. Krainak**, Photonics Branch, NASA Goddard Space Flight Center. CHARACTERIZATION OF SEMICONDUCTOR LASERS USING NONLINEAR OPTICAL METHODS. Direct electrical measurement of the high-frequency modulation characteristics of semiconductor lasers is challenging because of the difficulty in distinguishing effects that are intrinsic to the laser from those that are caused by electrical parasitics. Recently, techniques have been developed that eliminate this confusion by optically probing the laser and exploiting some of the nonlinear optical phenomena which occur in semiconductor lasers to determine the intrinsic laser dynamical parameters. This paper will discuss the origin of the nonlinear phenomena and describe the experimental apparatus currently under development to study the effect of optical interaction between sections of multisection devices on their modulation characteristics. Supported in part by the NASA JOVE Program.

Samiullah, M. and P. Rolnick. Science Division, Northeast Missouri State University. SYMMETRY CONSTRAINTS ON THE CLASSICAL SKYRMION. We derive the constraints on the solutions of the classical $SU(2)$ Skyrme model imposed by requiring that angular momentum (\mathbf{I}) and isospin (\mathbf{J}) be well defined under the general symmetry ($a\mathbf{I}_3 + b\mathbf{J}_3$). We show that for all non-trivial solutions ($a\mathbf{I}_3 + b\mathbf{J}_3$) must be 0, a/b must be an integer, and the profile function must be of the form:

$$\mathbf{F}(\mathbf{r}) = F\{(1 - A^2)^{1/2} \mathbf{z} + A[\mathbf{x} \cos((a/b)\phi + B) + \mathbf{y} \sin((a/b)\phi + B)]\}$$

($\mathbf{x}, \mathbf{y}, \mathbf{z}$ are Cartesian unit vectors; r, θ, ϕ are the usual spherical polar coordinates; F, A, B are undetermined functions of r, θ).

Vosnidis, G., J.F. Kunze. Department of Nuclear Engineering, University of Missouri-Columbia. GAS CORE NUCLEAR ROCKET PROPULSION FOR MARS MISSION. It was in 1969 when humanity attempted its first serious step of space exploration as NASA landed the first crew on the Moon. It seems that the "last frontier" for the human race is space. Serious limitations though, in rocket engine

design, are currently holding us earth-bound and subsequently from realizing the beginning of this exploration. The next step in our effort to explore space seems to be manned missions to planet Mars. It can be easily calculated that by using conventional chemical engine rockets such missions become exceedingly long for human endurance and tolerance. Alternative rocket propulsion plants that can produce enough thrust to accelerate a payload through space to high enough speeds must be investigated, tested and developed. Extensive research and testing has been done in the 1960's, by NASA, on the solid core nuclear rockets known as Nuclear Engine for Rocket Vehicle Application (NERVA). This presents a proven technology that NASA is planning to use for the initial trip to Mars. However, it can be argued that a Gas Core nuclear engine is a much more efficient design. This engine, when used, can drastically cut down on the travel time and so make such missions even more realistic and achievable. In this design the temperature limit restricting the solid core engine is being overcome by using the nuclear fuel and its moderator/coolant in a vapor form producing more than twice the specific impulse of the solid core engine.

Whitaker, Robert J. Department of Physics and Astronomy, Southwest Missouri State University. THE LUCASIAN PROFESSORS AT CAMBRIDGE: A PRELIMINARY REPORT. The publicity given to Stephen Hawking in the popular, as well as the scientific, press has noted that he holds "Newton's" Chair at Cambridge. While the Lucasian Chair of Mathematics was held by Newton, he was not the first to hold it. Who else has held the Chair from Newton to Hawking? This question will be discussed, and a trivia quiz on the subject will be given.

SENIOR DIVISION 1996

Agriculture, Entomology and Herpetology Section

Aide, Michael. Department of Agriculture, Southeast Missouri State University. POTASSIUM SELECTIVITY IN REFERENCE AND SOIL CLAYS. Cation exchange and its underlying mechanisms and chemical expression continue to be an area of active research in soil science. The purpose of this research was to determine if isomorphous substitution associated with a series of reference smectites and smectite containing soil clays show K^+ preferences using a binary system of the ions K^+ and Mg^{2+} . Batch techniques using the K^+ - Mg^{2+} cation pair were equilibrated, at constant ionic strength, to determine the preference of reference and soil smectites for K^+ . The preference for K^+ was directly related to the extent of tetrahedral Al associated with the reference smectites and to the presence of micaeous minerals in the soil clays.

Aide, Michael and Betsy Allen. Department of Geosciences, Southeast Missouri State University. METAL DISTRIBUTION IN ALLUVIAL SOILS HAVING A FLUCTUATING WATER TABLE. Fluctuating water tables may promote a cyclic oxic-anoxic soil environment, possibly initiating mechanisms responsible for the separation of Fe and other metals into complex mottling patterns and concretionary materials. The purpose of this experiment was to determine if soil reaction (pH) and drainage influenced the chemical composition of concretionary materials. Concretionary materials were separated and analyzed for Fe, Mn, Co, Ni, Cu, Zn, and Al. Similarly, these same elements were sequentially extracted from the clay and silt separates. Soil reaction was a major predictor in determining the chemical composition of concretionary materials, especially trace metals. Alkaline reactions dramatically associated with increased trace metal concentrations in the concretionary materials.

Aide, Michael, Betsy Allen, Teresa Duncan, Ann Elledge, Mark Ellerbusch, Amy Huskey. Department of Geosciences, Southeast Missouri State University. PRELIMINARY SCREENING OF THREE FLOODPLAIN SOILS OF THE MISSISSIPPI RIVER IN THE VICINITY OF CAPE GIRARDEAU, MISSOURI, FOR TOXIC LEVELS OF METAL. River systems that drain large industrial centers usually contain significant quantities of dissolved metals or metals chemisorbed onto bed sediments. Recent inundation of the Mississippi River floodplains may have placed trace amounts of heavy metals in the soilscape, especially in areas which received river sediments. The study was conducted to determine the possible extent of heavy metal deposition and to fractionate some selected metals to estimate their bioavailability. Three sites were established on flood prone landforms along the Mississippi River in the Missouri counties of Cape Girardeau and Scott. Soil profiles were classified, sampled and analyzed for routine characterization. Selected horizons were analyzed by neutron activation analysis (NAA) for heavy metals. Subsequently, selected samples were analyzed by a selective, sequential extraction procedure to estimate bioavailability. All metals within the surface horizon were comparable to the concentration of metals at some depth, suggesting that these areas are not being enriched in heavy metals. The bioavailability of selected metals show no evidence suggesting any potential environmental damage.

Carrel, J.E. Division of Biological Sciences, Missouri University-Columbia. RESPONSES OF PREDATORS TO CHEMICALLY DEFENDED PREY. Many insects, millipedes, and other members of the phylum Arthropoda have been shown to contain secondary natural products that seem likely to be used for defense against attacks by predators. But testing the effectiveness of a particular defense mechanism turns out to be exceedingly difficult in the field. A major difficulty is that a particular

defensive chemical may evoke one or more responses from a suite of many possible ones in any enemy. Furthermore, what holds for one species of predator may not hold for most other carnivores when tested in the same fashion. In addition to species-specific variation, one finds that an individual predator's experience and physiological state may either enhance or diminish its sensitivity to controlled stimulation by a defensive substance. A good generalization is that "No chemical defense is perfect" or "Every arthropod has at least some enemies". This tension between the prey's defense and its enemies' offense at the population level creates ecological variation and variation is what makes life interesting to a chemical ecologist. Currently scientists are presented with a dismal situation: as they begin to comprehend the wonders of arthropod chemical ecology, at the same time they also feel a mild terror knowing many of nature's biochemical systems are almost certain to be disrupted as thousands of species go extinct in the 21st century.

Kaps, M.L. and F.A. Einheilig. Department of Fruit Science, Southwest Missouri State University. **GROUND COVER FOR WEED SUPPRESSION IN AN APPLE ORCHARD.** The weed suppressive (allelopathic) property of cereal rye (*Secale cereale*) was used as an alternative to chemical herbicide under apple trees. The objectives were to determine if rye suppressed weeds and if it was competitive with trees. A completely randomized design was used with three or four single tree replications. Rye was seeded under trees in spring and fall 1993, and again in spring 1994. Untreated control and preemergent herbicide (simazine, norflurazon) were used as comparison treatments. In both years, apple leaf stomatal conductance ($\text{cm} \cdot \text{s}^{-1}$), change in trunk cross sectional area (cm^2), and shoot growth (cm) were not significantly different between treatments. The respective treatments: control, spring 1993 seeded rye, and herbicide had 100%, 73% and 16% weed cover at the end of the season. Fall 1993 and spring 1994 seeded rye were not significantly different and had 34% less weed biomass than the control with herbicide 63% less. Weed suppression was obtained with cereal rye ground cover, but less than with preemergent herbicide. Although no significant competition of rye with trees occurred, the potential for this exists. A management practice that left killed-rye as a ground cover residue during the growing season would minimize competition with trees.

Kuss, M.T., O.B. Mock, Department of Anatomy, Kirksville College of Osteopathic Medicine, and **J. H. Shaddy,** Division of Science, Northeast Missouri State University. **TOXICITY OF 1,3-DINITROBENZENE IN THE LEAST SHREW.** This study was a part of ongoing studies to evaluate the least shrew (*Cryptotis parva*) as a biomarker for assessing toxins in the environment. 1,3-Dinitrobenzene (DNB) is a common intermediate in the synthesis of pesticides, dyes and rubber chemicals. Toxic effects following the oral administration (14 day) of DNB to 50 ± 10 day old shrews included: splenomegaly, hepatomegaly, granulopenia, anemia and depressed plasma glutamic-pyruvic transaminase activity. No reduction in body weight, food consumption or reproductive organ weights was noted. Doses above 31.25 mg/kg were lethal and the no observable adverse effects level was 0.98 mg/kg. This is the first reported DNB subchronic oral toxicity study. The observed toxic effect are similar to those reported for other nitroaromatic compounds in other mammals. Supported by EPA grant CR823734010.

Wilson, Mack A. Department of Agriculture, Southeast Missouri State University. **VEGETABLE FARMING IN ROMANIA.** I received an Eisenhower Exchange Fellow whose office is based in Philadelphia, Pennsylvania. The purpose of my Fellowship was to work as a horticulture consultant on a twelve acre community development vegetable farm located in Cures de Arges, Romania. The farm was designed to produce vegetables for market in the town or community of Curtes de Arges.

Romania, being a former part of the communist regime, is considered a poor country. Money was siphoned away from the people through corrupt government practices and mismanagement. The result of a political upheaval has the people now living in primitive conditions and need help to feed themselves. Vegetable farming in Romania is still reliant on manual labor and manure fertilizer. Romania is at least 50 years behind other Western European countries or the United States in knowledge and farming technologies. Crops on the twelve acre farm were manually seeded, transplanted, watered, hoed or weeded, sprayed and harvested. My concerns along with the director of the community development project were to advise and setup demonstrations on modern farm techniques to assist the

farm manager in doing a better job. Some of the tasks that I was successful at doing were 1) setting up demonstrations of clear plastic and row covers on cabbage and potatoes in increase earliness of crops, 2) setting up drip irrigation systems in low tunnel greenhouses and 3) determining the feasibility and profitability of crops grown at the farm.

Wilson, Mack A., Victor A. Khan and Clauzell Stevens, Department of Agriculture, Southeast Missouri State University. GREENHOUSE SOLARIZING OF RECYCLABLE MEDIA FOR GROWING MARIGOLDS. An experiment was conducted to determine the influence of manure, and fertilizer, with and without solarization, on the growth of marigolds. Average plant height was significantly greater in media which was solarized and covered with a plastic film to retain heat. Leaf length was significantly greater in amended media with fertilizer application. Plants grown in covered media produced significantly more flower buds than those grown in non-covered media while flower numbers were significantly greater for fertilized plants. Plant fresh and dry weights were significantly affected by covering the media during solarization and the application of fertilizer. Media amended with manure significantly affected plant fresh weight only. Flower size showed significant interactions between all factors evaluated in this study.

Atmospheric Science Section

Glass, F.H. and R.W. Przybylinski. National Weather Service, St. Louis, Missouri. RAPID EVOLUTION OF A TORNADIC HIGH PRECIPITATION (HP) SUPERCELL. During the morning of 18 May 1995 a small cluster of multicellular storms traversed south central Missouri producing 2.0 cm hail. As the storm complex encountered an east-west baroclinic boundary in east-central Missouri the complex rapidly developed HP storm characteristics featuring a prominent BWER and deep persistent mesocyclone. The HP storm evolution and subsequent initial tornado touchdown occurred very rapidly over Jefferson county Missouri. The storm displayed cyclic behavior producing 2 tornadoes in Missouri and 12 tornadoes in Illinois. Detailed storm surveys revealed a series of five tornadoes tracks within a 20 mile square area in Monroe county Illinois. Each of the tornadoes (ranging from F0 to F2 intensity) appeared to be associated with a large parent mesocyclone located along the storm's Weak Echo Region (WER) capped by high reflectivities aloft. The storm gradually evolved into two bowing segments as it entered Washington and Clinton counties in southwest Illinois. Two weak tornadoes and areas of damaging winds were linked to the leading edge of the southern bowing segment while damaging winds were documented with the northern segment. A survey of the pre-convective environment and storm reflectivity-Doppler velocity structures from WSFO St. Louis (KLSX) of the HP storm will be presented.

Leftwich, P.W. Scientific Services Division, National Weather Service, Central Region Headquarters, Scientific Services Division. ESTIMATING PRIOR PROBABILITY OF SEVERE LOCAL STORMS. Probabilities allow forecasters to state their degree of certainty in forecasts issued to the public. A "prior" probability is currently valid, but may be adjusted as additional information is received. Climatological frequency serves as a fundamental prior probability. Relative frequencies of severe local storm occurrence within a local area, while that area is included in a valid outlook, watch, or warning also provide prior probabilities. Local areas around several Midwestern cities were studied. For this study, a "local area" was defined as within 30 nautical miles of a designated city. Missouri cities included were Kansas City, St. Louis, and Springfield. As an example of results, during spring and summer a daily climatological prior probability of severe local storm occurrence was estimated to be 7% in the vicinity of Wichita, Kansas. Probability increases when outlooks and watches include Wichita, reaching 83% when a severe local storm warning is issued. Details of the methodology, results for the above Missouri cities, and various refinements of probability estimates are discussed.

Przybylinski, R.W., S.M. Nolan, T.P. Schroeder and W.D. Bechtold, National Weather Service, St. Louis, Missouri; Department of Earth and Atmospheric Sciences, St. Louis University. JANUARY 20,

1996 SNOW EVENT OVER EAST CENTRAL MISSOURI. CHALLENGES IN FORECASTING A MESOSCALE EVENT. During the afternoon of January 20, 1996, a "narrow" swath of snow fell over portions of east central Missouri and southwest Illinois. The band of snow extended over 150 km in length but less than 60 km wide. Total snowfall amounts ranged from 2.0 to 10.0 cm over parts of east central Missouri causing numerous traffic accidents across the St. Louis metro area. A post analyses of winter mesoscale system was conducted to determine the performance of the 12th, and 24th forecast Eta-X and NGM outputs from PCGrids (0000 UTC, 20 January, 1996) to 00 h diagnostic fields (1200 UTC, 20 January and 0000 UTC, 21 January, 1996) from the St. Louis University (SLU) diagnostic program. Some of the fields examined included: 1) isentropic analyses, 2) frontogenetical forcing, 3) the role of upper-level jet streak influences, and 4) equivalent potential vorticity. An assessment of these forcing fields along with WSR-88D base reflectivity images at 0.5° and elevated slices from WSFO St. Louis (KLSX) will be presented.

Zacher, C.A., Atmospheric Electrical Research Organization and **G.V. Rao**, Department of Earth and Atmospheric Science, St. Louis University. FULGUROLOGY - THE NAME AND THE NEED FOR INTERDISCIPLINARY COMMUNICATION IN LIGHTNING SCIENCE. It is important to recognize that the scientific study of lightning by its nature is, and should properly be considered an interdisciplinary pursuit, although up to now there has been little acknowledgement among lightning's mainsteam disciplines and technologies to bear witness to that fact. We present here 1) A derivation of the term fulgurology to cover such research in the lightning-related disciplines. 2) Recognition of the considerable semantic confusion built up (historically and currently) over terms as used among and between standard scientific papers and popular oversimplified versions in the literature; as well as confusion in the interpretation of observations by a broad spectrum of individuals varying widely in their knowledge. 3) Recognition of the tendency for this situation to continue and persist into the future probably on an accelerating scale, perpetuating similar ill-fitting formulations and magnifying the confusion unless checked. We propose that communications between disciplines is key to the derivation of correct and useful data, and for a unified field.

Biology Section

Ashley, David C. Biology Department, Missouri Western State College. OBSERVATIONS ON THE NATURAL HISTORY OF A PRAIRIE ORCHID (*Platanthera praeclara*) IN NORTHWEST MISSOURI. Populations of the western Prairie Fringed Orchid (*Platanthera praeclara*) were monitored at three locations in northwest Missouri during the growing season of 1995. The three locations were: Helton Prairie (Harrison County), Tarkio Prairie (Atchison County) and Little Tark Prairie (Holt County). Eighty flowering individuals were observed at the three prairies. Thirty-two individuals were seen at Helton Prairie, forty-three were seen at Little Tark Prairie, and five were seen at Tarkio Prairie. Flowers bloomed within a three-week period beginning in mid June. By late July, flowers had senesced and seed pods were developing. There seemed to be no correlations between the size of the plant and the number of buds it produced, but plants producing more buds per stalk also tended to produce larger mature seed pods. Most buds (from 84% to 100%) observed on orchids at the three prairies eventually opened as flowers. This project was funded in part by the Missouri Department of Conservation and the Missouri Western State College Foundation, Inc.

Collins, C., N. Ercal, S. Oztecan, R.H. Matthews. Department of Chemistry, University of Missouri-Rolla. EFFECTS OF VARIOUS ANTIOXIDANTS ON LEAD-EXPOSED CHINESE HAMSTER OVARY (CHO) CELLS. Lead exposure in *in-vivo* and *in-vitro* models has been shown to affect almost all systems and can cause various biochemical disfunctions. Recent studies indicate that lead-induced damage primarily results from the disturbance of prooxidant/antioxidant balance in cells. Despite the knowledge that lead can induce oxidative stress, the usefulness of natural or synthetic antioxidants has not been fully explored. In the present study, we compared natural and synthetic antioxidants' effects in lead-treated cells. Chinese Hamster Ovary (CHO) Cells were incubated at various concentrations of lead acetate for 6 hours. The cells then were treated with either 1 μ M N-Acetylcysteine (NAC), 25 μ M

Succimer, 0.75 μM Captopril, 2 μM Taurine, and 50 μM Lipoic Acid and incubated for 7-10 days Following the incubation period, the colonies were stained, counted, and survival fractions were compared.

Cooney, T. Department of Biology, University of Missouri-St. Louis. QUANTITATIVE LIFE HISTORY DIFFERENCES OF THE OZARK SCULPIN, *COTTUS HYPSELURUS*. Life history phenotypes of the Ozark sculpin, *Cottus hypselurus*, were compared from the Gasconade River drainage (Little Piney Creek) and the Meramec River drainage (Huzzah Creek). The study design was based on the analysis of variance. Twelve riffles, six from each stream, were organized into six geomorphological and hydrological similarity. Life history data were analyzed using analysis of covariance. Length at maturity, and number of eggs per nest differed between streams ($p < 0.0001$). Sex ratio and timing of spawn were also different between streams. I analyzed the cost of maturing at a greater length for Little Piney sculpins versus the expected benefits of greater fecundity, growth, and condition. I found no correlation between maturity and these traits. Various hypotheses are presented to explain the differences in timing of spawn, number of eggs per nest, and sex ratios between the two streams.

DeBacker, M.D., J.S. Heywood and W.R. Weber. Department of Biology, Southwest Missouri State University. EXAMINATION OF ALLOZYME DIVERSITY IN THE GENUS *CASTANEA* AS EVIDENCE FOR POSSIBLE HYBRIDIZATION. *Castanea pumila* is an outcrossing, woody perennial native to the Southeastern United States. Once considered separate species, *C. pumila* var. *ozarkensis* (the Ozark Chinquapin) and *C. pumila* var. *pumila* were recently combined due to extensive morphological intergradation. One possible explanation for the observed geographic variability is hybridization between two incompletely isolated species. The geographic distribution of allozyme variation was estimated to examine this possibility. Only one of six loci assayed was polymorphic, yielding lower than average generic diversity ($H_E = 0.082$). However, the genetic differentiation among populations ($G_{ST} = 0.129$) is higher than expected for species with similar life histories. Genetic distance is correlated with geographic distance ($r = 0.633$, $p = 0.000$); although, examination of allele frequencies do not reveal statistically significant clinal variation indicative of a hybrid zone. Genetic drift is the most likely cause of differentiation, not reproductive isolation between the two varieties. Consequently, the data support the recent revision of the section. Supported by the Legacy Foundation.

Gambill, A., J.T. Cochran, N. Ercal, and R. H. Matthews. Department of Chemistry, University of Missouri-Rolla. POSSIBLE PROOXIDATIVE EFFECT OF δ -AMINOLEVULINIC ACID (δ -ALA) ON CHINESE HAMSTER OVARY (CHO) CELLS. Accumulation of δ -ALA, a component of the heme synthesis pathway, has been previously implicated in the induction of oxidative stress in lead exposed in vitro models. Oxidative stress occurs when the intracellular prooxidant-antioxidant balance is disrupted and can be quantitated by measuring glutathione (GSH) and malondialdehyde (MDA) levels. In the current study we measured GSH and MDA levels in CHO cells exposed to varying concentrations of δ -ALA. Cell survival and viability assays were also included. Preliminary results of long term survival assays showed a decrease in the amount of viable colonies when compared to a control.

Geist, Z.A. and J.F. Belshe. Department of Biology, Central Missouri State University. HABITAT SELECTION OF SCISSOR-TAILED FLYCATCHERS IN WEST-CENTRAL MISSOURI. Recent surveys and studies show the breeding range of Scissor-tailed Flycatchers have expanded from southwest Missouri to north of the Missouri River and east to the Ozarks. The purpose of this study was to compare habitat selection of scissor-tails between two natural divisions. Habitat variables such as tree height, diameter, nest height, nest orientation and tree density were used to compare two study areas. In each study area, there were nest sites and unused sites. No significance was found by ANOVA comparisons of tree heights and diameters. Chi-square analysis on frequency data are incomplete at this time but will be discussed. Supported by CMSU Sigma Zeta Chapter and CMSU Biology Alumni Fund.

George, J. and D. Castaner. Department of Biology, Central Missouri State University. VEGETATION OF THE CROSS-TIMBERS LIMESTONE GLADE IN HICKORY COUNTY. An MDC glade in Hickory county was characterized by species, biseasonal coverage, soil depth & pH, canopy closure, and light intensity. The Cross Timbers glade has a known recent burn history and is located on the Springfield Plateau region of the Missouri Ozarks. A total of 98 species were recorded, including: *Ophioglossum engelmanni*, *Bouteloua curtipendula*, *Carex crawei*, *Psoralea esculenta*, *Petalostemon candidum*, *P. purpureum*, *Linum straitum*, *Euphorbia missurica*, *Oenothera missouriensis*, *Aster sericeus*, *Rudbeckia missouriensis*, and *Echinacea paradoxa*. *Andropogon scoparius* and *Panicum virgatum* were the dominant species by estimated coverage in both spring and fall. *Echinacea paradoxa*, *Castilleja coccinea*, *Psoralea tenuiflora*, and *O. missouriensis* were all common in the spring. Important late season species including *R. missouriensis*, *Liatris squarrosa*, *Solidago nemoralis*, and *Houstonia nigricans* are common. Preliminary results indicated decreased occurrence of glade dominants in areas surrounding the glades. These areas were dominated by *Helianthus hirsutus*, *Ostrya virginiana*, *Quercus stellata*, *Rhus aromatica*, and *Zizia aurea*. Soil depths averaged 11.3 cm; in areas around the glade 12.6 cm; thus, prevention of clearing and burning apparently has resulted in an increase in soil depth and changes in dominance. This project was funded in part by MDC and CMSU.

Green, A.E., S.M. Todt, A.C. Gathman, and W.W. Lilly. Department of Biology, Southeast Missouri State University. A SMALL SCALE FILTRATION-ENRICHMENT METHOD FOR SELECTION OF *SCHIZOPHYLLUM COMMUNE* MUTANTS. Dissection of metabolic pathways and enzyme function is greatly facilitated by mutant analysis. We are interested in understanding the role of proteases in the normal autolytic function of the basidiomycete *S. commune*. The use of filtration-enrichment to isolate mutants from fungi is well established; however the method traditionally used for *S. commune* is difficult and prone to contamination. We have developed a smaller scale system using syringes and glass wool which overcomes these difficulties. Spores were collected from an *S. commune* dikaryon following 6 to 10 days of growth. Irradiation of spores with UV light for 60 seconds was used to induce mutations. Liquid growth-limiting medium was inoculated with the irradiated spores and resultant mycelia grown with rotary shaking at room temperature. Periodically during the subsequent six days germinated spores were removed by glass wool filtration. At the end of the incubation period, ungerminated spores were plated on non-limiting medium. The resulting mycelia were tested on both limiting and non-limiting medium.

Hummel, K.H., A.R. Penheiter, A.C. Gathman and W.W. Lilly. Department of Biology, Southeast Missouri State University. RELIABILITY OF PROTEASE MOLECULAR WEIGHT ESTIMATION USING GELATIN-CONTAINING SDS-PAGE. Gelatin-containing SDS-polyacrylamide gel electrophoresis (SDS-PAGE) has become an important technique for analysis of proteolytic enzymes. Many researchers have used the method for determining the molecular weights of proteases without concern for the reliability of these estimates. We compared the separation of five proteases in both standard SDS-PAGE gels and gelatin-containing SDS-Page. Samples of chymotrypsin, trypsin, papain, elastase and ScPrB, a protease found in *Schizophyllum commune*, were normalized for protein content and electrophoresed in gels of various acrylamide concentrations. For standard SDS-PAGE, gels were blotted onto a second polyacrylamide gel which contained gelatin for detection of protease activity. Gelatin appeared to retard migration of all proteins, with 10 kDa standards running approximately 15-20% slower. Proteases ran at a much slower rate than predicted from the standards, and the results were not consistent from one protease to the next. This suggests that molecular weights estimated from gelatin-containing SDS-PAGE gels are not valid.

Joost, H. and M.C. Amspoker. Department of Biology, Westminster College. FLORRAL CALCIUM OXALATE CRYSTALS AS FORAGING CUES FOR HONEY BEES. Calcium oxalate crystals have been found near the areas of dehiscence in the anthers of various unrelated, entomophilous plant families. Various hypotheses have been proposed to explain the function of these crystals. We hypothesize that these crystals may serve as a visual cue that allows insect pollinators to distinguish

between mature anthers with ripe pollen and immature anthers. In order to determine whether or not honey bees (*Apis mellifera* L.) respond to calcium oxalate, honey bees from a feral colony were trained to visit an artificial flower patch composed of flowers with and without nectar guides composed of calcium oxalate crystals. Results of these experiments indicated that trained honey bees chose flowers with calcium oxalate nectar guides 73.3% of the time over flowers with other types of nectar guides. These data suggest that honey bees responded to the presence of calcium oxalate crystals, and that these crystals may serve as a reward-correlated foraging cue.

Kimmerle, K.A. Department of Biology, Central Missouri State University. **MIGRATIONAL STAGING OF PURPLE MARTINS (*PROGNE SUBIS*) ALONG THE UNITED STATES GULF COAST.** I studied the ecology and migrational staging of Purple Martins (*Progne subis*) on bridge structures along the United States Gulf coast. Twelve roosts were identified, of which eight were studied during a four-year period starting in 1992. Nightly roost assemblage, morning foraging dispersal, and trans-Gulf migration events were observed at at least five of the roosts. A definitive pattern existed in the type and location of the bridges selected. Nine of the ten bridges were constructed primarily of concrete and eight were greater than 1.0 mile in length. All bridges spanned open water, were relatively flat in their design, and were associated with river systems which drain into the Gulf of Mexico. Traffic density varied from less than two vehicles per hour to more than 30,000 per day.

Lee, K. and G.D. Sells. Division of Science, Northeast Missouri State University. **EFFECT OF DROUGHT STRESS AND OSMOTIC STRESS ON PROLINE AND SUCCINATE IN MITOCHONDRIA FROM CORN SHOOTS.** Plant mitochondria respond to drought stress by changes in rate of respiration as well as by different responses of enzymes. For example in mitochondria from drought-stressed plants, respiration was found to be minimally reduced when succinate was being oxidized but exponentially reduced when proline was being oxidized. A major objective of this study was to determine if the response of mitochondria to stress was signaled by a change in osmotic potential or by some other unidentified signal that exerted its effect on the mitochondria before they were isolated. The results of the study indicate that mitochondrial enzymes probably respond to a drought-stress signal from outside of the mitochondria. Varying the sucrose concentration of the reaction media during oxidation of both proline and succinate was observed to have only a minimal effect on respiration of mitochondria from turgid plants. However, a significant reduction in oxidation of proline was observed when respiration of mitochondria, isolated from drought-stressed shoots, was measured with an oxygen electrode. The activity of proline oxidase was also found to be significantly reduced when measured by the reduction of a blue dye (DCIP). The results from this study suggest that the reduction of activity of proline oxidase, but not the osmotic pressure, appeared to be the primary cause of the decrease of proline oxidation.

Nash, Sean and John Rushin. Department of Biology, Missouri Western State College. **COMMONNESS CHANGES IN LOESS HILL PRAIRIE PLANTS IN NORTHWEST MISSOURI AFTER A SPRING BURN.** This study involves a survey of the plants in a loess prairie located on private property along the south border of the Star School Prairie Conservation Area in Atchison County, Missouri. The study area was lightly grazed and was burned only one time (April 1992) in recent years. Several plants found are listed by the Missouri Department of Conservation as rare, endangered or watch list species. A quadrat survey showed that *Andropogon scoparius*, little bluestem, was by far the most common species over a 5-year period (1990-1994). Other common grasses were *Muhlenbergia cuspidata*, plains muly grass, *Bouteloua hirsuta*, hairy grama, and *Bouteloua curtipendula*, sideoats grama. The tallgrass *Andropogon Gerardi*, big bluestem, was very infrequent prior to the 1992 burn but it became the second most common plant in the study area during the two growing seasons following the burn.

Neal, R., N. Ercal, S. Oztecan, R.H. Matthews. Department of Chemistry, University of Missouri-Rolla. **NATURE OF RADIOPROTECTION BY N-ACETYLCYSTEINE ON CHINESE HAMSTER OVARY CELLS.** N-Acetyl cysteine (NAC) is a well-known antioxidant and potential radioprotector for

in vivo and in vitro systems. There are two proposed mechanisms by which MAC could act: 1) by the direct action of its sulfhydryl group, or 2) by acting as a precursor for cysteine and thence glutathione (GSH) intracellularly. In order to distinguish between these mechanisms, we decided to study the chiral specificity of the action of NAC. We irradiated Chinese Hamster Ovary (CHO) cells in vitro to various doses employing 9 MeV electrons. One half hour preceding this, we added 5 mM L-NAC or D-NAC to the media. The cells were incubated for 7-10 days and formed colonies which were then stained and counted to determine survival fraction of the original cells. We also measured intracellular GSH levels in the presence or absence of either enantiomer. Our results seem to support a protective mechanism involving the synthesis of GSH.

O'Dell, R.B. and S. Carroll. Science Division, Northeast Missouri State University. EFFECTS OF BURNING AND CLEARING ON *VIOLA PEDATA* AS MEASURED BY SEED SIZE VERSUS SEED NUMBER. The objectives of the experiment were to determine the effects of prairie and savannah restoration practices (burning and clearing) on reproductive allocation of two varieties of *V. pedata*. This should provide feedback for future restorations regarding treatment effects on resource allocation to seeds in prairie savannah forbs. Wild populations of *V. pedata* were used with four treatments: forested burned, forested not burned, open burned, and open not burned. These sites were located at Thousand Hills State Park and Big Creek Conservation area, both located in Adair County, MO. Shading structures were used to mimic forest light levels in the open sites while hand pollinations were done as a test of pollen limitation. Preliminary analysis suggests that the disturbed sites had fewer seeds per fruit and a smaller seed mass than plants which were undisturbed and in the open. The disturbed plants also had more seeds and larger masses than those from undisturbed and under canopy sites.

Roberts, A.D., M.C. Barnhart, A. P. Farnsworth. College of Natural and Applied Sciences, Southwest Missouri State University. LIFE HISTORY OF THE FLAT FLOATER MUSSEL, *Anodonta suborbiculata*. Due to habitat loss, the flat floater mussel is considered to be one of the rarest naiades in Missouri. In order to develop a management plan to protect the species, several aspects of its life history and physiology were investigated. Ten fish species and bullfrog tadpoles were tested as potential hosts by artificially infecting them with flat floater larva (glochidia). Successful transformation occurred on warmouth, white crappie, largemouth bass and golden shiners. Sperm release was observed in mid-September through early October, and glochidia were fully developed by late October. Glochidial release from female clams was complete by late February. To test the ability of this species to estivate, impedance electrodes were used to monitor heartbeat of juvenile and adults placed in conditions similiar to a drying lake. Adult and juvenile flat floaters were found to be intolerant of immersion lasting only an average of 10 days. Age distributions were deduced from shell dimensions of 300 flat floaters from several localities. These data suggest that individuals and populations of flat floaters may be relatively short-lived. Individuals grow rapidly and reproduce at a young age, but populations may not persist for a long period of time. Supportd by Kansas Wildlife and Parks.

Sharp, J.R. Department of Biology, Southeast Missouri State University. EMBRYOLARVAL EFFECTS OF EXPOSURE DURATION TO MERCURY BY PERCID SPECIES, *Etheostoma caeruleum* AND *Etheostoma spectabile*. Four to eight cell stage embryos of each species were exposed to 0-100 μ g Hg⁺⁺Cl⁻¹ (mercuric chloride) continuously, 4-d, 2-d and 1-d through hatching. Five replicates of 10 embryos each were incubated at 18° C during the 24-h static renewal toxicity test for each concentration and each exposure duration time. Time to hatch, as well as ova diameters differ between the two species. *Etheostoma caeruleum* (*Ec*) requires 12-d to hatch and has an ova diameter of 1.9 mm, while *E. spectabile* (*Es*) hatches in 8-d and has an ova diameter of 1.2 mm. The ova diameters obviously influence surface area:volume ratios. Median effect {50% responses} concentrations (MECs) were determined for 96-h mortality, 7-d abnormality, total hatching success, and viability of hatch. As expected, *Ec* embryos and larvae of the continuously exposed treatment resulted in lower MECs than *Es* however, the MECs of 4-d, 2-d and 1-d exposure treatments to *Ec* were likewise lower, even through the percent time of exposure to mercury was decreased. Plausible explanations will be presented.

Stribling, A.M. Department of Biology, Southwest Missouri State University. **THYROID HORMONES AND THE ONSET OF HIBERNATION IN THE 13-LINED GROUND SQUIRREL, *SPERMOPHILUS TRIDECIMLINEATUS*.** None of the various endocrine glands thought to play a role in hibernation have been more thoroughly studied with more conflicting results than the thyroid gland. In most species, the thyroid gradually becomes less active throughout late spring and summer, and virtually ceases activity by time the animal initiates hibernation. If a reduction in thyroid hormones is a physiological cue or prerequisite for entering hibernation, then blocking thyroid hormone secretion and/or activation may induce premature hibernation. Conversely, keeping thyroid hormones elevated may prevent hibernation, or delay its onset. Thirteen-lined ground squirrels ($n=7$ per treatment) were given propylthiouracil (PTU: 0.01%) in their drinking water to block thyroid function, in combination with a long photoperiod or naturally decreasing photoperiod, and either cold (10°C) or warm (25°C) temperature. Control animals ($n=7-9$ per treatment) were kept in the same environmental conditions without the PTU. In a second study, 14 ground squirrels were injected with either 500ng or 5000ng of L-thyroxine daily in an attempt to delay the entrance into hibernation. Entrance into hibernation was defined as 48 continuous hours of torpor. Blood samples were taken initially, and once hibernation started, by cardiac puncture to determine serum concentrations of free and total thyroxine (T_4), and free and total triiodothyronine (T_3). Preliminary analysis of the data suggest that PTU did not induce early hibernation, but both doses of thyroxine injection appeared to delay the onset of hibernation. A more detailed analysis, in addition to photoperiod and temperature interactions, will be discussed.

Vildiz, D., N. Ercal, Department of Chemistry, **R. Frank,** Department of Life Sciences, **R.H. Matthews.** Department of Chemistry, University of Missouri-Rolla. **EFFECTS OF 4-HYDROXYNONENAL (HNE) ON MYC-INDUCED APOPTOSIS.** Apoptosis has been described as programmed active cell death characterized by a requirement for protein synthesis. Overexpression of the c-myc gene has been shown to induce apoptosis in Rat1A/Myc-ER cells when these cells are combined with a growth blocking agent. In the present study the incidence of apoptosis in serum deprived Rat1A/Myc-ER cells was confirmed photographically and by ladder pattern formation seen on agarose gel electrophoresis. In order to study the effect of HNE on Myc-induced apoptosis in serum deprived cells, the cells were cultured in 0.5% serum and treated with various concentrations of HNE. Myc was then activated by $2\mu\text{M}$ β -estradiol. Two separate parameters were used to determine the rate of cell death. In the first, the amount of DNA isolated from dying cells was compared by UV absorption both in the absence and presence of HNE. As the second parameter, the cell number was determined by counting. Although $1\mu\text{M}$ HNE had no effect of apoptic death, $10\mu\text{M}$ HNE decreased the amount of DNA isolated while increasing the cell count 14% relative to only β -estradiol treated cells. Our results suggest a dose dependent inhibitory effect for HNE on Myc induced apoptosis in serum deprived Rat1A/Myc-ER cells.

Chemistry Section

Carter, K.N. Jr. and J.M. Young. Division of Science, Northeast Missouri State University. **COMPARISON OF CLOSED-FORM AND BOOTSTRAP CONFIDENCE INTERVALS FOR ENDPOINTS OF CONDUCTOMETRIC TITRATIONS.** As advances in analytical chemistry have increased the use of multivariate statistics, spawning the speciality of chemometrics, computationally intensive methods are sometimes employed, especially in cases where closed-form expressions for confidence limits are nonexistent. Our previous research identified reliable parametric methods for conductometric titrations. Comparison provides a test for the reliability of a popular nonparametric method. Bradley Efron's bootstrap method uses resampling from the original set of data to generate synthetic data sets from which replicate values of the statistic of interest may be calculated. We compare the results of resampling the points themselves to the results of resampling the residuals of the original least-squares fit. We confirm Efron's own cautions that calculating nonparametric confidence intervals

requires a large number of bootstrap replications. Even several hundred replications may be inadequate for agreement with results from Fieller's theorem, through further refinements may improve the match.

Engineering Section

Cox, N.R. Department of Electrical Engineering, University of Missouri-Rolla. VIDEO DATA COMPRESSION BASED ON VIEWER DISTRACTION. For more than 30 years, researchers have made use of both the psychovisual properties of the eye and statistical source-coding methods to develop algorithms that significantly compress analog and digital picture signals without perceptible degradation. It would seem that the possibility of obtaining further levels of high-quality compression would be slim, at best. However, recent work has shown that further compression is indeed possible when the viewer is temporarily distracted by action or the message content of the picture. For example, subjective tests have shown that, in certain cases, it is possible to predict where the attention of all

viewers will be focused. This means that picture areas outside of this area of focus can be compressed significantly without detection by the viewer. This paper discusses the results of preliminary subjective tests that have been conducted and provides an estimate of the amount of compression that can be obtained. A method of encoding based on eye movement is proposed. Practical applications are also discussed.

Varma, V.K. and M. Najafi. Department of Engineering Technology, Missouri Western State College. FEASIBILITY STUDY: REHABILITATION OF A 20-INCH C.I. SEWER FORCEMAIN. A feasibility study was conducted to determine the viability of different trenchless methods for rehabilitation of an existing 20-inch diameter cast iron sewer force-main, approximately 8,000 ft. in length, and located along a railroad right-of-way. The cast iron pipe is approximately 35 years old, and has a history of ruptures with longitudinal and circumferential cracks. The study includes the focus on causes of pipeline ruptures, unique conditions of the pipe, and examines in detail the potential pipeline rehabilitation methods, such as, cured-in-place pipe (CIPP), sliplining, in-line replacement, close-fit pipe, and point source repair. Cost estimates and parameters for design of the new pipe including design calculations are presented.

Venezian, Giulio V. Department of Physics, Southeast Missouri State University. EFFECT OF SAMPLING ON THE STATISTICS OF WAVE HEIGHTS AND PERIODS. Wave motion can be characterized by the statistical probability of occurrence of heights and periods. For a wave consisting of a simple superposition of two sinusoids, the statistics derived from wave sampling differ from the theoretical predictions. The difference can be attributed to the sampling rate. Modifying the theory to account for the sampling rate gives a close correspondence between theoretical and observed results.

Geography Section

Albrecht, M.S., M. T. Aide and G. J. Cwick. Departments of Geosciences and Agriculture, Southeast Missouri State University. USE OF LANDSAT TM DATA TO ISOLATE SODIUM ACCUMULATION IN SELECTED SOILS OF STODDARD COUNTY, MISSOURI. An area on the east side of Crowley's Ridge in the southwest portion of Stoddard county was evaluated using Landsat Thematic Mapper (TM) multispectral data to determine the location of soil sites having elevated sodic concentrations which can be detrimental to crops such as corn and soybeans. These sites were earlier sampled (Aide et al., 1995) and their location noted using the Global Positioning System (GPS). Spectral signatures correlating with the high sodic soils were collected and input into a supervised classification algorithm which produced a map of these and other sites throughout the region. Further assessment, via change detection methods performed on two TM data sets from the summers of 1984 and 1988, was made to ascertain the extent of sodic conditions over this timeframe and gather insight into whether this is an isolated situation or expanding process. Preliminary indications suggest that

seasonal moisture variations have occurred which contribute to the development of greater sodium amounts and that there appears to be an increasing trend of sodic deposition in this area.

Albrecht, M.S. and G. J. Cwick. Department of Geosciences, Southeast Missouri State University. **MONITORING THE EFFECTS OF OVER IRRIGATION WITHIN A PORTION OF THE AMU-DAR'YA RIVER BASIN, UZBEKISTAN USING LANDSAT MSS DATA.** During the 1970's and 1980's, considerable quantities of water were diverted from the Amu-Dar'ya river which drains into the Aral Sea for use to grow agricultural crops (predominantly cotton) in what is now Uzbekistan. One of the most obvious consequences of this diversion has been the dramatic decrease in the size of the Sea itself (approximately 40%). Additionally, there is concern that such irrigation has contributed to increased saline conditions in this region. To determine the extent of salination that has occurred there, a multitemporal analysis of Landsat Multispectral Scanner (MSS) data was conducted in the southwestern portion of the Amu-Dar'ya river basin directly south of the Aral Sea. Two MSS image scenes acquired of the area during September 1973 and September 1989 were first processed using image enhancement methods, such as ratioing and principal components analysis (PCA), to spectrally isolate landcover features suspected of being saline in character. These were verified using available surface-truth information. Image data having such features were then spatially registered and analyzed using change detection techniques to quantify their areal variation over the 16-year period. Initial results confirm that there has been an increase in salinization over this timeframe sufficient enough to expand the breadth of existing features (e.g., salt playas) and reduce the productivity of soils in this part of the basin.

Corcoran, W.T. Department of Geography, Southwest Missouri State University. **USE OF THE WORLDWIDE WEB IN THE ATMOSPHERIC SCIENCE CLASSROOM.** The Internet and the graphical interface known as the World Wide Web (WWW) provide access to numerous weather map servers that can be used in an atmospheric science classroom. In addition, recent changes in the distribution format of weather data now allow virtually any institution to receive virtually real-time weather data, map it, and put it on the web for classroom use. The Unidata project of the University Corporation for Atmospheric Research distributes both the data-ingestion and data mapping programs for free. In addition, Unidata also supervises the distribution of the data. All this is free. The Department of Geography at SMSU maintains such a system, and its use in the daily life of Geography 135 Atmospheric Science will be illustrated. Hands-on work with the web will be provided.

Grabow, Albert J. Department of Social Science, Crowder College. **CURRENT VIEWS OF ANTI-GOVERNMENT UNREST IN MEXICO.** Violence against the establishment PRI government in Mexico is becoming quite serious. Indian groups calling themselves Zapatistas were in open battle with the Mexican Army in the South in 1993 and 1994. In April 1994, the PRI presidential candidate was assassinated in Tijuana. Although election fraud was a big issue, the 1994 election still resulted in continued PRI control. By March 1995, massive anti-government rallies were being held nightly in the Main Square (Zocalo) of Mexico City.

This program will focus on the presenter's 35mm slides of anti-government demonstrations in the Zocalo, March, 1995, and a discussion of the political and economic background of Mexico today. Also to be included will be a description of the Zapatista Net of Autonomy and Liberation as found on the Internet. The site describes itself as "the vanguard of proactive revolutionary autonomous recombinant electronic multimedia."

Johnson, J.S. Department of Geography, Geology and Planning, Southwest Missouri State University. **VISIBILITY IN HERCULES GLADES WILDERNESS.** Hercules Glades Wilderness was designated a class I airshed by the Clean Air Act Amendments of 1977. The Clean Air Act requires the United States Forest Service as Federal Land Managers, to protect class I airsheds from the adverse effects of anthropogenic air pollution. In 1991 a visibility study was initiated by the Forest Service in conjunction

with Southwest Missouri State University and a private landowner, as a component of a nationwide visibility study.

The Hercules Glades Visibility monitoring station is located on private land that borders the Wilderness. The site includes a meteorological station, an automatic camera, and three rain gauges. The solar powered computer module stores up to forty-five days of hourly data. The camera takes a picture at 9:00 am, 12:00 pm, and 3:00 pm each day on 64 ASA Kodachrome slide film. The secondary target is 8.2 kilometers away, and the primary target is 26.3 kilometers from the camera. Air Resources Specialists, Inc. is analyzing the film. Standard Visual Range (SVR) and Slide Condition are two types of analysis being performed. Variations and frequencies of visual range will be further analyzed.

Visibility thresholds will be determined following the administration of a public perception study. Policy implications will include renewed support of the Clean Air Act. The collection of baseline data is important because it allows federal land managers to make future comparisons of air quality data. This research will help to determine if anthropogenic activities are affecting the air quality over this class I airshed.

Geology And Geophysics Section

Anderson, N.L., D. Lawson, M. Roark. Department of Geology and Geophysics, University of Missouri-Rolla. COMBINED SEISMIC AND GROUND PENETRATING RADAR SURVEY FOR DELINEATING SUBSURFACE GEOLOGIC STRUCTURES. The Geophysics special topics class recently assessed the potential of combining seismic and ground penetrating radar (GPR) surveys to image the possible downward continuation of surficial geologic structures. In a roadcut located 5 miles north of Licking, Missouri on Highway 63, highly deformed Roubidoux sandstone provided an excellent test site. The GPR survey consisted of 4 sweeps across a 400-ft. line using a GSSI-SIR8 system with a 500Mhz antennae/receiver. The system operated at 12.8 scans/s using an optimum 100ns time window to image depths of about 5.3 m. The high resolution shallow reflection seismic survey produced similar results. A 24-channel stacking seismograph permitted 12-fold data acquisition with a 10-ft. geophone spacing and 30-ft. offset. Interpretations of both survey profiles indicate the possible presence of basement faulting and sink formation in underlying karst. This result provides evidence that combined geophysical surveys possess significant investigative potential.

Ciftci, E. Department of Geology & Geophysics, University of Missouri-Rolla. HAZARDOUS COMPONENTS OF CONTAMINATED SOILS NEAR A LEAD SMELTER AND THEIR POSSIBLE SOURCES. Reflected light microscopy (RAM) in conjunction with electron probe microanalysis (EPA), transmitted light microscopy (TLM), scanning electron microscope-energy dispersive spectroscopy (SEM-EDS), and cathodoluminescence (CL) was utilized to determine the phases present in both soils and dusts, their chemical compositions, and their textures. Soils collected from the area surrounding a lead smelting plant were found to be composed mainly of slag particles that entrap environmentally deleterious lead carrying phases as metallic blebs, pyrite, hematite, cuprite, goethite, and magnetite in a glass matrix. The source of the contamination consists of dusts from the lead blast furnace (LBF) and lead sinter plant that are abundant slag particles resulting from the recycling of slag from the lead smelter to the sinter plant, coke, sinter and lesser amounts of chalcopyrite. Galena particles were the most abundant component in dusts from the sinter plant as expected since it is the main constituent in the concentrate feed to the sinter plant. Dust samples from the lead blast furnace (LBF) consists of relatively high amounts of sinter and coke particles. Reflected light microscopy (RAM), aided by electron probe microanalysis, forms a very useful approach to the study of the speciation of metals in dusts and soils. Supported by Nigde University in Turkey.

Cui, Yuzhi, John M. Holbrook, Timothy Ray and M.D. Raghunath. Department of Geosciences, Southeast Missouri State University. ARCHITECTURAL-ELEMENT ANALYSIS AS A TOOL FOR MODELING OF UPPER DAKOTA SANDSTONE IN CENTRAL KANSAS. Detailed architectural-element analysis was conducted at twenty-nine outcrops in central Kansas in order to define Dakota geometric building blocks for input into a geometric simulator of aquifer heterogeneity. Field

observation revealed that these upper Dakota strata are dominated by five architectural elements, each with distinct geometries and abundance. These are channel-fill (44%, ribbons), overbank-fine (27%, tabular), sandy-bedform (17%, prismatic), lateral-accretion (6%, lobate), and foreset macroform (6%, lobate). These elements imply deposition primarily from a meandering system. Our stochastic model uses these field data to predict elements where data is absent using growth likelihood probabilities and a Monte Carlo simulation technique.

Hampton, L.B. and P. Berendsen. Kansas Geological Survey, University of Kansas. PRECAMBRIAN METASEDIMENTARY ROCKS IN THE SUBSURFACE OF WESTERN MISSOURI: PRELIMINARY DATA. Low-grade Precambrian metasedimentary rocks make up approximately 20% of the basement of eastern Kansas and western Missouri. A large area of the sedimentary rocks occur between the NW trending Bolivar-Mansfield and Chesapeake tectonic zones which extend from western Missouri into eastern Kansas. Other metasedimentary rocks are found in the proximity of the Nemaha Tectonic Zone in Kansas. What little is known about these rocks has been gained through examination of drill cuttings and core, in addition to geophysical methods. Preliminary study indicates that these low-grade, clastic metasedimentary rocks consist mostly of quartzite and feldspathic quartzite. Intervals of meta-argillite, and meta-graywacke are observed, however metamorphic texture is not distinct in all cases. Epidote and rhyolitic fragments are seen in some samples.

Preliminary geochronologic data, and the presence of rhyolite clasts, suggest that deposition was subsequent to anorogenic magnetism of the 1.35-1.40 Ga Spavinaw Granite-Rhyolite terrane. More work needs to be done to more tightly constrain the timing of deposition, and to determine if the rocks may be related to the Midcontinent Rift, as suggested by previous studies.

The goal of this study is to determine the provenance of the sedimentary rocks, and to constrain the timing of their deposition, as well as to define their structural setting, in an effort to gain insight into the region's Meso-Neoproterozoic tectonic history.

Hoffmeister, A.P. Department of Geology and Geophysics, University of Missouri-Rolla. THE DINOFLAGELLATE FLORA OF THE LATE OLIGOCENE-EARLY MIOCENE OLD CHURCH FORMATION. The Old Church Formation is a unit in the mid Atlantic Coastal Plain whose age and stratigraphic position are problematic. Outcrops are rare, limited in thickness and extent, display intense bioturbation and contain poorly preserved macrofossils. Three outcrops and four cores containing the Old Church formation were sampled and examined for dinoflagellate cysts to determine the age and depositional environment of the Old Church Formation. Analysis of the dinocysts produced two distinct floral assemblages which restricted the age of the Old Church Formation to late Oligocene and/or early Miocene, although ambiguity with respect to the exact placement of the unit still exists due to observed overlap of species whose published ranges are exclusive. There are four possible resolutions of this problem, each yielding a distinct placement for the Old Church Formation. Old Church sediments were deposited in a subtropical, neritic setting.

Holbrook, J.M. Department of Geosciences, Southeast Missouri State University. RECOGNITION OF A SEQUENCE BOUNDARY WITHIN VALLEY-FILL STRATA OF THE MUDDY SANDSTONE IN SOUTHEASTERN COLORADO. Detailed study of Muddy lithofacies architecture reveals a regional sequence-bounding unconformity within these valley-fill strata, indicating that valley filling proceeded in two aggradational stages which were interrupted by an unconformity-developing erosional phase. Three principle lines of evidence distinguish this mid-Muddy sequence boundary. First, this boundary is everywhere marked by an abrupt upward transition from estuarine to fluvial channel-fill strata, or can be traced laterally into such a surface. Second, the aforementioned boundary can be traced continuously along strike over 20 km of continuous outcrop in the Huerfano Canyon, and is locally incised deeply into underlying strata. Lastly, fluvial channel fills above and below this bounding unconformity contrast distinctly and consistently. Channel sandstones are dominated by planar cross bedding above, and trough cross bedding below this surface.

Roark, M.S. and N. Anderson. Department of Geology and Geophysics, University of Missouri-Rolla. APPLICATION OF GROUND PENETRATING RADAR IN THE EVALUATION OF KARST FEATURES IN ROADCUTS. Ground penetrating radar (GPR) was used to map dolomite and sandstone rock outcrops in the Rolla, Missouri area. Many of these outcrops displayed evidence of karst activity, folding, or faulting. Ground penetrating radar is a non-invasive shallow subsurface investigative technique that allows the user to acquire a high resolution profile of the subsurface structure. In the past decade, the utility of this geophysical technique has increased significantly. Results of five surveys are presented here. Local geological information is provided to establish structural and lithologic control. Photo mosaics of the roadcuts were taken to establish a quality correlation between the radargrams and the actual features of the outcrops. The quality of the survey data ranged from poor to excellent.

Ryckman, D.A. Department of Geology and Geophysics, University of Missouri-Rolla. TEXTURAL EVIDENCE FOR THE PRIMARY CRYSTALLIZATION OF THE PLATINUM GROUP MINERALS: THE STILLWATER COMPLEX, MT. This investigation consisted of the study of 12 polished sections from the ore zone of the Stillwater Pt/Pd Mine using optical techniques, as well as SEM/EDS analysis. Previous investigations performed on the PGM occurrence within the Stillwater Complex have noted their close association with the major sulfide phases pyrrhotite, pentlandite and chalcopyrite. Their close proximity to the hydrous deuteric phase, serpentine have raised questions as to the timing of their crystallization during emplacement of the intrusive. I will present textural evidence which shows that, not only were the PGM crystallized from interstitial fluids during initial cooling of the magma, but they also predate the major sulfides pyrrhotite, pentlandite and chalcopyrite. Evidence for the dissociation of Ru and Os from Pt and Pd will also be offered. This investigation is continuing to study the processes leading up to saturation and subsequent crystallization of the PGM at the ore horizon. Knowledge of the timing of PGM crystallization during the intrusion of mafic/ultramafic magmas should lead to a better understanding of the process and aid in the search for these ore minerals.

Sanchez, I. and N. Anderson. Department of Geology and Geophysics, University of Missouri-Rolla. SHALLOW SEISMIC REFLECTION SURVEY ON AN INFERRED ZONE OF FAULTING AND FOLDING IN LACLEDE CO., MISSOURI. Geologic strata belonging to the Jefferson City Dolomite are observed in Laclede Co. along state hwy. 5; the observed structures suggest a system of faults and folds. The object of this project was to study the structure using shallow seismic reflection methods in order to determine its nature and the extent to which it penetrates the subsurface. A seismic survey was conducted 16 miles north of Lebanon, Missouri. The interpretation of the seismic data confirmed that the observed outcrop structure is the result of folding and faulting, rather than the result of dissolution of dolomite. Faults and folds were identified at depths of 200 to 300 feet and are assumed to be the result of important compressional events in the area.

Stewart, Kimberly L., John W. Cash, and Richard D. Hagni. Department of Geology and Geophysics, University of Missouri-Rolla. REFLECTED LIGHT MICROSCOPY OF ACCRETIONS DEPOSITED IN A DIRECT IRON REDUCTION FURNACE. The mineralogy and textures of accretions formed in a direct iron reduction furnace has been studied using reflected light microscopy. The direct reduction furnace is a new steel-making technology for directly reducing iron ores to produce steel, a process that is more efficient, less costly and safer than conventional blast furnace and Bessimer processes. An important problem in some reduction furnaces is that of the formation of deleterious accretions in the off-gas vent. This mineralogical study of the accretions has shown that they consist of metallic iron, wuestite, pyrrhotite, pseudobrookite, akermanite-ferroakermanite, gehlenite, magnetite, and hercynite spinel. Textures include metallic iron spheres, wuestite and pyrrhotite in rapidly deposited eutectic intergrowths, and euhedral crystals of the silicate minerals, akermanite, gehlenite, and spinel. Current research is focusing on the mineralogical and textural differences between accretion samples collected from various portions of the vent. The results of this research will provide a better determination of the manner in which each phase was deposited and the causes for formation of the accretions. Research supported by University of Missouri-Rolla OURE fund.

Wright, W.R., A.N. Mariano and R.D. Hagni. Department of Geology and Geophysics, University of Missouri-Rolla. THE MINERALOGY OF THE ELDOR CARBONATITE, LABRADOR TROUGH-QUEBEC: PRELIMINARY RESULTS. The Eldor carbonatite complex has received no modern mineralogical or petrographic study. Helicopter-supported field exploration discovered the occurrence in July 1985. Recognition of a radiometric anomaly associated with thorium prompted study of the complex. Anomalous niobium up to 7 wt %, anomalous tantalum up to 0.1% and the presence of pyrochlore, columbite and rare-earth minerals, including bastnaesite, makes further study of this deposit extremely interesting. Preliminary petrographic analysis of Eldor specimens, obtained by chain-sawing glacially striated boulders, has shown the presence of pyrochlore, galena, chalcopyrite, pyrrhotite, pyrite, and rare-earth minerals. Pyrochlore is the probable host of the anomalous amounts of Nb allowing elemental substitution at the A, B, and X sites. Darkfield microscopy proved useful in identifying pyrochlore and readily shows the chemical zonations within individual crystals. This investigation of the Eldor carbonatite will include: cathodo-luminescence microscopy, scanning electron microscopy with x-ray dispersive spectrometry, wavelength dispersive microprobe analysis and geochemistry (major trace and rare-earth element) in addition to the transmitted and reflected light microscopy currently in progress.

Yepes, O., C. Jaramillo and F. Oboh-Ikuenobe. Department of Geology, University of Missouri-Rolla. RECONSTRUCTION OF PALEOBATHYMETRIC CURVES FROM PALYNOFACIES ANALYSES: EXAMPLES FROM CRETACEOUS AND LATE PALEOGENE ROCKS FROM COLOMBIA AND THE GULF COAST. Quantitative and qualitative palynofacies analyses combined with detailed lithofacies data from five sections from the Cretaceous of Colombia (South America) and the Late Palogene of the U.S. Gulf Coast have been used to reconstruct paleobathymetric curves for these stratigraphic intervals. Eleven different types of organic matter were recognized under transmitted light microscope. Cluster analysis of these organic matter types with a detailed lithofacies analyses formed the basic framework for paleoenvironmental interpretations. Paleobathymetric curves derived from these techniques are a good approach for analyzing relative sea level changes, movements of the shoreline, and basin-wide chronostratigraphic correlations.

Physics Section

Anderson, R.A. Department of Physics, University of Missouri-Rolla. RESULTS OF SOFTWARE SURVEY. The software survey of physics teachers had two objectives. First, the survey indicated the use of program language, mathematics packages, and spread sheets by the instructor in class preparation and by the student in homework assignments. Second, the survey was to indicate the names of the software being used to indicate if common packages are used. The results of this survey will be reported.

Broerman, J.G. and J.K. Zuo. Department of Physics and Astronomy, Southwest Missouri State University. MOLECULAR BEAM EPITAXY IN AN UNDERGRADUATE RESEARCH PROGRAM. Molecular Beam Epitaxy (MBE) is a state-of-the-art technique used to grow artificially structured materials on the nanometer scale. With its requirement for an ultra-clean, ultra-high vacuum (10^{-10} mbar) environment and its reliance on sophisticated analytical tools for *in situ* growth control and characterization, it is generally felt to be beyond the scope of undergraduate research projects. However, if integrated into the research group early in their careers and exposed in course work to modern and solid state physics, the students are by the senior year able to perform growths, characterizations, and data analyses with good understanding of the underlying physics. We will show some of the work done by students in our program of research on III-V compound semiconductor growth.

Chattopadhyay, Soumitra. Department of Science and Mathematics, Columbia College. SEMI-EMPIRICAL QUANTUM MECHANICAL STUDIES ON DIMERS OF HYDROGEN SULFIDE.

Electronic structure calculations have been performed using semi-empirical methods for two dimers of Hydrogen Sulfide. Results for the optimized structures, vibrational and rotational constants, charge distribution, and other related properties will be discussed.

Chyba, D.E. Division of Science, Northeast Missouri State University. NEW METHOD FOR FINDING BIFURCATIONS FROM ZERO INTENSITY IN A SEMICLASSICAL MODEL OF A RING LASER WITH A SATURABLE ABSORBER. This talk describes a new method of completing the mathematical bifurcation diagram of the solutions of a semiclassical model of a ring laser with a narrow bandwidth intracavity saturable absorber. The model is based on the Maxwell-Bloch equations in the slowly-varying amplitude and uniform field approximations, assuming plane wave solutions and homogeneously broadened two-level atoms. The media may be detuned away from the optical cavity modes and from each other. It is typical in such models for solutions at zero intensity to be incompletely defined. Various indirect methods have been used to define such solutions in order to complete the theoretical bifurcation diagram for a given model. The model equations described here are in a form which directly yields a complete analytic solution for the case of zero intensity. This method of solution is outlined and its results are compared to those of the indirect methods.

Di Stefano, M.C. Division of Science, Northeast Missouri State University. RETHINKING THE GOALS AND CHARACTERISTICS OF THE LABORATORY EXPERIENCE IN INTRODUCTORY PHYSICS COURSES. In recent years, efforts at various levels have challenged the traditional structure of introductory physics courses. Many of the concerns raised in rethinking these courses, however, may be addressed just by modifying the laboratory experience to depart from the standard quantitative verification of known laws and principles. I will present examples from an array of different types of lab activities which have been used in an algebra-based, one year course. The activities support the overall goals of the course, fostering and enhancing conceptual understanding, the development of transferable skills, and highlighting connections with applications and the real way of doing physics.

Giedd, R.E. and T. H. Owen. Department of Physics and Astronomy, Southwest Missouri State University. ADAPTATION AND MODIFICATION OF A COMMERCIAL ION IMPLANTER FOR USE IN A UNIVERSITY INSTRUCTION ENVIRONMENT. We have rebuilt an ion implanter, previously used in research and on an IBM semiconductor manufacturing line, for use as an instructional tool in both graduate and undergraduate research project courses. In modifying this production tool we have two purposes: first to expose the students to process of making transistors and integrated circuits; and second to give them some degree of practical training on an instrument widely used in the electronics industry. With scientists anticipating a more competitive job market in the late 1990's, it is very important to educate students with as much practical experience as possible. The results from this project are quite promising, as indicated by student participation. Our implementation of this experience in course work, the modifications to the instrument, the internet features, and safety considerations will be discussed.

Kapoor, Yogendra M. Department of Natural Sciences and Mathematics, Lincoln University. STRUCTURAL STUDIES OF SOME CARBON BLACKS AND SILICAS USING SMALL-ANGLE X-RAY SCATTERING. The structures of some carbon blacks and some silicas were investigated on length scales from about 5 to 10,000Å using small-angle x-ray scattering. Equations developed for structural studies of fractal and non-fractal aggregates of primary particles were used to analyze the scattering data. From the scattering data, the average diameters of the primary particles could be calculated. Despite the very different origins of the sample and the average diameter of the particles varying from 30 to over 1000Å, the scattered intensities from the samples had many common features. The data showed that the primary particles had a uniform density and were bounded by smooth or fractal surfaces. On length scales greater than the diameters of the primary particles but not more than a few times larger than the average diameters of the aggregates, some of the aggregates were mass fractals, and others were surface fractals.

Lindevald, I.M. Division of Science (Physics), Northeast Missouri State University. **BREAKING THEM IN: A FRESHMAN PHYSICS SEMINAR.** The immediate need for incoming freshman students, who intend to major in the physical sciences, to develop higher math skills, causes most to delay the onset of their general physics survey courses until the second semester of the freshman year. This delay produces an intellectual void in students' careers at the worst possible time, just when they are most excited about setting out on a specialized course of study. Students with a high potential to succeed in physics may lose interest during that first semester, and students with misconceptions about physics and engineering may lose that time in which they could be learning in another field. Over the last several years, a seminar course has evolved at NMSU that is designed to fill the void by providing students with useful tools for future laboratory work, as well as relevant information on what the student should expect from an education in the physical sciences, and on the options available to them after graduation. Many of the important issues addressed in this course have no other natural forum within the standard physics curriculum. Unique aspects of this course, which involve active learning and group activities and which are designed to develop students' critical thinking skills, will be discussed fully.

Mayanovic, Robert A. Department of Physics and Astronomy, Southwest Missouri State University; **Alan J. Anderson,** Geology Department, St. Francis Xavier University, Canada; and **Sasa Bajt,** University of Chicago. **MICROBEAM X-RAY STUDIES ON FLUID INCLUSIONS.** Microbeam XAFS using synchrotron radiation is a promising new technique for in situ structure studies on microscopic regions in heterogeneous materials primarily because it is element specific and sufficiently sensitive for trace elements. We have previously demonstrated the usefulness of micro-XAFS for structure studies of individual fluid inclusions at room temperature. In this study, we seek to determine the structure of zinc complexes in fluid inclusions at elevated temperatures. Zn K-edge XAFS spectra were collected in the fluorescence mode using a Si(Li) detector from a hypersaline fluid inclusion (c.a. $\sim 60\mu\text{m}$ in diameter) in quartz, in the temperature range from 25°C to $\sim 430^\circ\text{C}$. The x-ray optics included using a single Si(111) channel cut monochromator, a 8:1 Al(Pt-coated) focusing mirror and a pinhole aperture positioned at the focal plane. Our results indicate a predominance of ZnCl_4^{2-} complex in the liquid phase of the inclusion even at the highest temperature. These studies should shed some light on the chemical and physical nature of metal complexes occurring in both natural and synthetic multicomponent solutions under high pressure and temperature.

Samiullah, M. Discipline of Physics, Division of Science, Northeast Missouri State University. **VERWEY TRANSITION IN MAGNETITE: FINITE TEMPERATURE MEAN FIELD SOLUTION OF THE CULLEN-CALLEN MODEL.** Verwey transition in magnetite (Fe_3O_4) will be reviewed, and studied by solving the Cullen-Callen spinless one-band model at finite temperature. A complete phase diagram in the $(U/t, T)$ -plane will be presented, and it will be shown that the model contains three phases, one disordered and two ordered phases. The transition corresponding to the Verwey temperature is seen to be of first order.

Schoof, Timothy D. and Raymond M. Stevens. Park College. **MULTI-CULTURALISM IN SCIENCE.** A course designed to enhance student awareness of our multicultural scientific heritage is discussed. Focus is upon the nature of scientific inquiry and the factors affecting the participation of diverse groups of individuals in the advancement of science, especially physics and chemistry. Demonstrations, classroom experiences, and student reactions to the incorporation of multiculturalism in physics will be presented.

Velasco, E. Sanchez. Science Division-Physics, Northeast Missouri State University. **THE RELATIVISTIC KEPLER PROBLEM AND THE PRECESSION OF THE PERIHELION OF MERCURY.** We present a simple modification of Newton's theory of gravity for the gravitational potential produced by the Sun by adding an extra term of relativistic origin. We determine the form of the new term by requiring that it produces the correct value for the precession of the perihelion of Mercury and the other planets. To find the precession of the perihelion we solve for the trajectory using

the new gravitational potential and special relativity mechanics. This is necessary because the contribution to the precession of the perihelion due to special relativity is of the same order of magnitude as the contribution from the gravitational corrections. The orbit equation is no longer that of a pure central potential, as in Newtonian mechanics, because the mass of the planet that appears in the gravitational force depends on the velocity. The solution of the equations presents some subtleties that make it very interesting as an advanced problem in undergraduate mechanics.

Venezian, Giulio V. and Simon L. Kiefer. Department of Physics, Southeast Missouri State University. EXPERIMENTAL STUDY OF RESONANT WAVE TRAPPING IN A VIBRATING WIRE. The experiment involved waves propagating along a steel wire. Waves were trapped between a mass attached to the wire and a fixed point. Wave amplitudes were measured outside the mass and in the region between the mass and the fixed point. The measured values for the ratio of the amplitudes agreed well with theoretical predictions.

Whitaker, Robert J. Department of Physics and Astronomy, Southwest Missouri State University. THE PSSC "SCIENCE STUDY SERIES": WHAT WAS IT? In 1959 the Physical Science Study Committee (PSSC) produced a textbook, *Physics*, a number of 16 mm films, and began a series of supplemental books published by Doubleday Anchor. By the time the series ended in 1974 seventy-two books had been produced. Nearly one-third are still in print with several having undergone revision. The series and the reprints will be discussed.

Science Education Section

Borowicz, K.L. Division of Education, and **J. M. Osborn.** Division of Science, Northeast Missouri State University. USING COMPUTER-BASED, THREE-DIMENSIONAL RECONSTRUCTION TO ENHANCE STUDENT COMPREHENSION OF PLANT ANATOMY. Many students enrolled in structurally oriented biology courses have difficulty three-dimensionally conceptualizing the internal ultrastructure/anatomy of cells/organs. To enhance their ability to comprehend such structures, we have introduced into a university-level Plant Anatomy course the utilization of a DOS-based computer program that three-dimensionally reconstructs biological structures. Serial sections of a cell or an organ are digitized into the computer. These sections are then aligned, thus, creating a graphic three-dimensional reconstruction of the structure in question. To further student comprehension of internal anatomy, the reconstruction can be examined at different rotational angles. Moreover, specific components can be emphasized or de-emphasized in order to highlight various characteristics. The computer-generated reconstruction can also be output to a printer for use in laboratory reports, videotaped as a 'movie' by rotating the reconstruction in X, Y, and Z planes, or photographed for presentation and/or publication.

Chyba, D.E. Division of Science, Northeast Missouri State University. AN EXPERIMENT ON TRANSISTOR ELECTRONICS IN A COLLEGE PHYSICS COURSE FOR NON-SCIENCE MAJORS. This presentation describes a laboratory experiment and associated apparatus used for introducing electronics into a college physics course for students who are not majoring in science. The experiment introduces the students to the collector voltage-base voltage and emitter voltage-base voltage characteristics of a transistor with collector and emitter resistors. The graphs of these characteristics are used as a basis for understanding the operation of simple but effective amplifier circuits. The application of this understanding is illustrated by the construction of a simplified two-stage audio amplifier, with a telephone handset used for input and output. Two groups of lab students can connect their units to make a two-station intercom.

LaBundy, J. and P. Wilson. Division of Science, Northeast Missouri State University. THE PATH TO CONSERVATION THROUGHOUT AMERICAN HISTORY: PLEASE DO NOT WALK ON THE RARE PLANTS. Modern conservation in the United States is the culmination of a long history of changing philosophical approaches, advancements in science, and legislative measures. The latest major

effort proposed by the federal government, The Endangered Species Act, affords legal protection to endangered plants as well as animals. Despite this coverage, federally endangered plants do not share the same protection "rights" as their animal counterparts. Likewise, funds allocated to endangered species have been biased toward animals. Historically, arguments for the conservation of plants have differed, as have reasons for conservation in general. Upon examining the ideas and motivations of past conservation leaders, and the development of ecological science, the reasons for rare plant protection become evident, as do the reasons behind the lingering discrepancy in the protection of rare plants and rare animals.

Lawson, M.D. Department of Library Services, Central Missouri State University. UNTANGLING THE WEB: A CASE FOR WORLD WIDE WEB HOME PAGES FOR FACULTY MEMBERS IN THE SCIENCES. Due to changing addresses, vanishing sites and newly established links, the Information Superhighway is becoming a traffic nightmare. Faculty are in need of accessing the Internet without wasting valuable time and energy. One method for eliminating this problem is to construct and maintain a Home Page for individual departments and disciplines. However, Home Pages are only as good as the amount of effort put into them. Using HTML and following specific guidelines and tips in the building of a Home Page could accomplish this task. With clear, well-defined ideas for establishing a Home Page, a workable Web site for the faculty in a subject-specific area could be created and maintained. This could be done by appointing a departmental staff member and/or by utilizing the expertise of your library liaison (bibliographer). By following specific criteria and avoiding the pitfalls that detract from a scholarly Home Page, your creation should be a useful site for others to connect to other useful web sites.

Mills, S.H. Department of Biology, Central Missouri State University. STUDENT RESPONSES TO USE OF DATA ACQUISITION IN THE PHYSIOLOGY LABORATORY. Student evaluations of the animal physiology laboratory were obtained over a series of semesters. During this time, both the approach and the instrumentation were changed to include computer data acquisition (CDA). The purpose was to provide a more open-ended approach. Resource material is available from Hypercard stacks. Improved instrumentation interfaced with CDA permits experiencing all components of the scientific method rather than concentrating on data collection. About 50% of the students own their computer while over 85% have access to computers. After 2 semesters with one CDA system, 6 CDA systems replaced all chart recorders. Students report that more than one lab period is needed to become familiar with the CDA. Students compared two systems (MacScope and MacLab) with and rated both as useful or very useful compared to the chart recorder. Both CDA were found to be more convenient and easier to use in preparing lab reports. Nearly all students have rated CDA as very useful or useful compared to chart recording. Data manipulation is perceived to be as easier with the CDA. Most students do not think computer simulations should replace animal experiments. Most do believe teacher/student interactions are increased with CDA. Support was provided by the NSF's Division of Undergraduate Education through grant DUE-#9452535.

Roy, P., R. Aram and D. Henne. Education Department, Drury College, Evangel College, Pleasant View Middle School. AN INTERACTIVE MODEL ON TEACHING WATER QUALITY MANAGEMENT. To provide opportunities for the continuing education and professional development of science teachers in rural schools is both a need and a challenge. An attempt was made to provide opportunity for in-service teachers to upgrade their knowledge on water quality monitoring techniques and integrate them appropriately in their curriculum. An intensive six-day Summer workshop was offered for 21 teachers teaching science and math in the surrounding area. Emphasis was given on content training, curriculum development, hands-on laboratory and field work on local streams. This project was funded by an Eisenhower grant provided by the Missouri Coordinating Board for Higher Education. It was based on a partnership between Drury College, Missouri State Department of Natural Resources, local water protection agency and schools in adjoining watersheds. The evaluations obtained from the participants were satisfactory. Various implementation models were used by different

participants. A middle school teacher implemented a successful after school model that enhances her science curriculum.

COLLEGIATE DIVISION 1996

Biology Section

Anderson, J.M., A.E. Plymale, L. Xun, and H. Bolton, Jr. Environmental Microbiology, Pacific Northwest Laboratory and Washington State University. TRANSPORT OF NITRILOTRIACETATE (NTA) INTO THE NTA DEGRADING BACTERIUM *CHELATOBACTER HEINTZII*. Nitriilotriacetic acid (NTA), a synthetic chelator, has been used to decontaminate nuclear reactors and in nuclear materials processing. The co-disposal of synthetic chelating agents with radionuclides has resulted in increased radionuclide migration in the subsurface. Understanding the mechanism of NTA degradation, including transport into the cell, is essential to mitigate the migration of metal-NTA complexes in the subsurface. In our study, the presence of 1 mM Ca in pH 7 HEPES buffer significantly enhanced the transport of 5 μ M NTA into the cell in comparison to Na, K, or Mg. Transport of NTA with Ca displayed saturation kinetics at 1 μ M NTA, while transport without Ca appeared to be by diffusion. Transport of NTA with Ca was inhibited by sodium azide, dinitrophenol, and CCCP, suggesting active transport requiring ATP. These results suggest that the Ca-NTA and perhaps other metal-NTA complexes may be actively transported into the NTA degrader. Research supported by the U.S. Department of Energy SERS fellowship under contract DE-AC06-76RLO 1830.

Baxi, S.S. C.T.Healey and G.D. Sells. Department of Biology, Northeast Missouri State University. EFFECT OF VARYING SUCROSE CONCENTRATION ON RESPIRATION OF MITOCHONDRIA ISOLATED FROM MAIZE SHOOTS. Water stresses affect how a plant responds. In the mitochondria it may alter substrate usage so that it may continue to respire despite periods of flooding and drought. In this study, the rate of respiration in mitochondria of corn shoots was measured during the oxidation of three substrates (exogenous NADH, succinate and proline) while varying the sucrose concentration. The variation in sucrose molarity is representative of the water stresses that a plant may encounter. Respiration rates and RCRs (Respiratory Control Ratios) were calculated for three substrates at three different sucrose molarities (0.05M and 0.35M sucrose compared to the control of 0.2M). The RCRs for the control, succinate, ranged from (1.31 to 2.71) for 0.2M, and (1.11 to 1.70) and (1.02 to 2.24) for 0.05 and 0.35, respectively. RCRs for NADH were also calculated and were found to be slightly higher while those of proline were found to be slightly lower. A comparison of the substrate's effects on respiration within a single category of sucrose molarity was made, with succinate standardized to 100%. Proline and NADA were compared with succinate which served as a control. The respiration rate of NADH was much higher in comparison to proline and succinate. The range of such a deviation appears to be less significant in a 0.2M reaction (as opposed to in a 0.05M or a 0.35M). Support for materials was supplied by the Division of Science.

Best, A.B. and P. Gabrielson. Department of Biology, William Jewell College. ASSESSING PHYLOGENETIC RELATIONSHIPS AMONG RED ALGAE USING 18S RIBOSOMAL DNA. Using PCR and direct sequencing of the nuclear genes encoding 18S small subunit ribosomal RNA, partial sequences have been obtained from the freshwater red alga *Compsopogon coeruleus* currently classified in the subclass Bangiophycidae and the articulated coralline red alga *Calliarthron tuberculosum* currently classified in the subclass Florideophycidae of phylum Rhodophyta. Phylogenetic analysis based on molecular sequences is a useful tool in resolving phylogenetic relationships among problematic groups such as Bangiophycidae which remains polyphyletic. The sequence of *C. coeruleus* obtained was 1689 base pairs with a guanine+cytosine content of 53.2%. The 18S rDNA sequence of *C. coeruleus* is compared with the 18S rDNA sequences of other red algal species within subclass Bangiophycidae and with representatives of subclass Florideophycidae

Bradley, D.A., C.L. Phillips. Department of Biochemistry and Child Health, Division of Medical Genetics, University of Missouri-Columbia. **SITE-SPECIFIC MUTAGENESIS OF THE MURINE PRO α 2(I) COLLAGEN EXPRESSION GENE: UNDERSTANDING THE ROLE OF CROSSLINKING.** Type I collagen is the major structural protein in the body, providing strength and integrity to bone, tendon and skin. It's monomeric form is a heterotrimer comprised of two α 1(I) chains and one similar, but genetically distinct α 2(I) chain. It is hypothesized that intermolecular crosslinks between these collagen molecules are principal determinants of the stability, biomechanical and physicochemical properties of the fibrillar matrix. To investigate the role of tissue specific type I collagen crosslinks, we created two pro α 2(I) collagen expression genes in which we introduced amino acid substitutions at the specific loci responsible for mature crosslink formation, a telopeptide lysine (skelatal tissue specific) and a triple helical domain histidine (skin specific). These conservative substitutions, the first a lysine to an arginine, and the second a histidine to glutamine, render these loci unavailable for crosslink formation. The modifications were made by utilizing site-specific mutagenesis, following the protocol of Deng, W.P. & Nickoloff, J.A. (1992: *Anal. Biochem*, 200:81). The presence of the substitutions was verified by 1) PCR amplification and restriction digest (modification also created new restriction sites), and 2) dideoxy-mediated chain-termination DNA sequencing. These constructs will allow us to address the role of crosslinking in the biomechanical properties of skin and bone on a controlled genetic background.

Brown, A.E. and P.A. Tipton. Department of Biochemistry, University of Missouri-Columbia. **REFOLDING STUDIES OF DIMETHYLALLYL PYROPHOSPHATE: 5'AMP TRANSFERASE (DMAT) EXPRESSED AS A RECOMBINANT PROTEIN IN *ESCHERICHIA COLI*.** Cytokinins are plant hormones that may control many growth and developmental processes in plants. DMAT is responsible for the committed step in the biosynthesis of the cytokinin precursor, isopentenyladenosine monophosphate (iP). Two *Agrobacterium tumefaciens* genes, *tze* and *ipt*, code for DMAT. The *tze* gene product has been expressed in *E. coli*, however, the expressed protein is insoluble. A number of strategies have been investigated to refold DMAT into its active conformation after denaturing the protein in 8M urea. DMAT is assayed for activity by first hydrolyzing pyrophosphate, one product of the DMAT catalyzed reaction, and then measuring the amount of phosphate present in the reaction solution. This assay has given reasonable evidence that some of the refolding strategies have yielded active DMAT. In the future a new expression system for both the *tze* and *ipt* genes in *E. coli* will be studied. In the new system, DMAT will be expressed fused to thioredoxin in the hopes that the fusion protein will be soluble and that cleavage of thioredoxin will yield active DMAT.

Dickey, C.E., J.C. Polacco, and S.K. Freyermuth. Department of Biochemistry, University of Missouri-Columbia. **ROLE OF ARGINASE IN PLANT NITROGEN METABOLISM.** The amino acid arginine is a major storage form of seed protein nitrogen in plants. Because nitrogen plays an important role in seed germination, arginine levels must be maintained at an appropriate level. Arginase, the enzyme that breaks down arginine into ornithine and urea, is involved in the mobilization of seed protein during germination. In order to understand better the role of arginase in plants, we plan to alter arginase levels in *Arabidopsis* to look at the effects of overexpression and elimination of arginase activity on the plant. To this end, we are cloning the arginase gene into a binary vector in the antisense orientation. Since cloning the arginase gene in the sense orientation, this plasmid, in *Agrobacterium*, has allowed us to produce transgenic *Arabidopsis* plants. We will begin observing the effects on germination, seed set, and overall growth. Assays will then be performed.

Fisher, M.D. Science Department, Webster University. **FRESH WATER MUSSELS AT TWO SITES IN THE MERAMEC RIVER, MISSOURI.** Shells of fresh water mussels (Bivalvia: Unionoidea) were collected in 1995 from two sites on the Meramec River in St. Louis County, Missouri. Site 1 collection is dominated by *Actinonais ligamentina* (Lamarck), *Megaloniais nervosa* (Rafinesque), and *Amblema plicata* (Say); Site 2 (7 miles east of site 1) is dominated by *Quadrula quadrula* (Rafinesque), *Amblema plicata* (Say), and *Fusconia flava* (Rafinesque). Total species at the two sites is fifteen. There is significant variation in the species composition between the two sites which could be related to stream

flow, channel gradient and substrate. Federal Candidate (Category 2) for Endangered species List *Cumberlandia monodonta* (Say) was located at site 1.

Flake, N.M. and T.E. Phillips. Division of Biological Sciences, University of Missouri-Columbia. CELL VIABILITY AS EVALUATED USING CALCEIN AM AND ETHIDIUM HOMODIMER. Chemical, cosmetic, and pharmacological manufacturers seek to replace the Draize eye test with an alternate physiologically relevant *in vitro* assay to assess irritation due to caustic substances. We used the HT29-18N2 goblet cell line derived from the human intestinal epithelium as a model for the conjunctival cells affected in the Draize eye test. HT29-18N2 cells, like cells in the conjunctiva, synthesize and secrete mucins to form a lubricative and protective layer against irritants. Our goal was to first establish the threshold concentration of an irritant that would cause death in the HT29-18N2 cell line and then screen sub-lethal doses for their ability to provoke mucin secretion. To establish the lethal threshold concentration, we tested a commercially available cell viability assay in which a cell-permeable, fluorescent green dye (calcein AM) is used to stain living cells and a cell-impermeable, fluorescent red dye (ethidium homodimer) is used to stain dead cells. Cells were exposed to varying concentrations of irritants and then incubated in a mixture of calcein AM/ethidium homodimer for 60 min. This assay was found to be unsatisfactory for three reasons: First, after exposure to presumed lethal treatments (e.g., up to 24 hrs in 2% paraformaldehyde), some cells continued to contain only the fluorescent green dye indicative of a living cell. Second, some irritants (e.g., a 60 min exposure to 35% methanol) caused all but a few cells to detach from the coverslips; analysis of only the remaining cells would have been a biased determination of viability. Finally, despite being exposed to an excess of non-specific irritants, cells within a monolayer appeared to die in a non-homogeneous fashion. This unexpected problem precluded the use of morphometric analysis of a small sample of cells to estimate the mucin secretory response of a monolayer.

Ford, B.W. and C. Newlon. Department of Biology, William Jewell College. COMPARISON OF SMALL MAMMAL POPULATIONS IN VIRGIN AND RESTORED TALLGRASS PRAIRIE AREAS IN NORTH-CENTRAL KANSAS. The purpose of this study was to sample mammals in a virgin and restored prairie at the Land Institute in Salina, Kansas. With the increased concerns about the impacts of human land practice on wildlife, it is important to understand habitat distribution and requirements for native mammals, especially those living in disturbed prairie areas. One hundred traps were used totaling 500 trapnights. Sixty one mammals were captured in both areas with 19 recaptures. Four species were caught, they were *Sigmodon hispidus* (Cotton Rat), *Reithrodontomys megalotis* (Harvest Mouse), *Perognathus hispidus* (Hispid Pocket Mouse), and *Microtus ochrogaster* (Prairie Vole). *S. hispidus* had the highest percent abundance in both areas, 90.4%. *R. megalotis* had the second percent abundance in both areas, 4.8%, *P. hispidus* and *M. ochrogaster* had the lowest percent abundance with 2.4% each. Twenty eight of the 38 *S. hispidus* were captured in the restored prairie, this could be due to the patchy vegetation and greater percentage of bare ground than was found in the virgin prairie. The remaining 3 species accounted for only 4 individuals, 2 *R. megalotis*, 1 *M. ochrogaster* and 1 *P. hispidus*. These species were caught at the outer edges of the areas away from the main *S. hispidus* captures. *S. hispidus* may be a dominating species that drives out other species from an area. Supported by the Department of Biology, William Jewell College.

Frahm, A.M. and A.K. Sakai. Department of Biology, William Jewell College and Department of Ecology and Evolutionary Biology, University of California, Irvine. GENDER-SPECIFIC PHYSIOLOGY IN TREMBLING ASPEN, *POPULUS TREMULOIDES* (SALICACEAE). Male and female clones of trembling aspen, *Populus tremuloides*, were studied on the Pellston Plain in northern lower Michigan to determine if there were any physiological differences between sexes. Measurements included photosynthetic rate (A), stomatal conductance (g), water-use efficiency (A/g), chlorophyll concentration, specific leaf area, water potential (Ψ), and stomatal density. Females had greater stomatal conductance, lower water-use efficiency, and higher specific leaf area than males. There were no significant differences between males and females in the photosynthetic rate per area, chlorophyll

concentration, mid-day or pre-dawn water potentials, or stomatal density. Females may exhibit these physiological differences to compensate for the greater cost of reproduction. Because the Pellston Plain has such a low density of clones of a relatively young age, females currently may not be experiencing the trade-offs associated with gender-specific physiological differences, such as greater differential mortality with greater competition. Supported by an NSF REU program grant.

Frahm, A.M. and C.F. Newlon. Department of Biology, William Jewell College. POPULATION AND DISTRIBUTION OF THE BARN OWL, A RARE SPECIES IN MISSOURI. Recent research shows that the common barn owl, *Tyto alba*, has become rare or uncommon throughout most of the Midwest in the past thirty years. While researchers know the population is declining, the owls' true distribution, population level, food habits, and habitat needs are not known in each area where the owls are found. The purpose of this study was to determine the distribution and food habits of the barn owl in Missouri. A total of 263 pellets were collected from 8 sites, seven along the western border of the state and one in the northcentral region. The mean weight of each pellet was 6.86 g and an average of 2.6 prey were found per pellet. Pellet content analysis showed that vole species were a very important constituent of the owls' diet. *Microtus* spp. and *Synatpyomys cooperi* were found in the pellets at every site, were frequently the most abundant type of prey captured, and composed 62-91% of the biomass at five of the eight sites. *Reithrodontomys megalotis* was an important secondary source of food, comprising 2-42% of the biomass, and *Sigmodon hispidus* constituted a range of 0-74% of the total biomass consumed, taking equal importance in the diet as the voles in the western part of the state. In addition, prey content in the pellets also reflected the distribution of small mammals in the state.

Gibbs, S.R., A. Clapper, and F. Rodriguez. Division of Neurosurgery. University of Missouri-Columbia. PERCUTANEOUS LATERAL TRANSILIAC APPROACH TO THE L5-S1 INTERVERTEBRAL DISC SPACE. We describe a technique to access the L5-S1 intervertebral disc space through a percutaneous transilliac route. This technique requires fluoroscopy and the Elson biopsy set (Cook Company) for spine lesions. This set contains a serrated trocar that may be used to create access through the iliac bone immediately below the posterior superior iliac spine. Using fluoroscopy, a 22 gauge needle is advanced through the iliac window toward the L5-S1 intervertebral disc space keeping the needle under the retroperitoneum. A blunt cannula is advanced over the fine needle in an atraumatic fashion until contact is made with the annulus fibrosus. This procedure has been performed on two patients without complications for biopsy of disc material, wherein an infectious process was suspected and ultimately confirmed. One procedure was aborted due to radicular pain reported by the patient. The pertinent anatomy of the lumbar plexus and great vessels and their relationships from this approach to the L5-S1 intervertebral disc space will be presented. In summary this is a safe, relatively simple technique to access the L5-S1 intervertebral disc space for biopsy and may prove to be useful for endoscopic lumbar discectomy at this level.

Gust, J.E. and S.F. Nothwehr. Division of Biological Sciences, University of Missouri-Columbia. ANALYSIS OF THE RELATIONSHIP BETWEEN CLATHRIN HEAVY CHAIN GENE AND OTHER GENES REQUIRED FOR LATE GOLGI PROTEIN RETENTION. An organelle in the secretory pathway, known as the Golgi apparatus, is essential in segregating proteins for specific destinations such as the vacuole or exterior of the cell. The Golgi is able to retain certain resident proteins important for its function while permitting many "transient" proteins to pass through to other destinations. A group of yeast mutants, called the *grd* mutants (for Golgi retention defective), define at least 18 complementation groups exhibiting various characteristics with regard to Golgi membrane protein retention. The relationship of these *GRD* genes to a previously identified gene (*CHC1*), that encodes clathrin heavy chain, has been investigated. *CHC1* has been shown to be required for Golgi retention and other cellular processes such as endocytosis. Double mutants were made to explore any synthetic phenotypes between a *CHC1* temperature sensitive allele and *grd* mutants. Genetic interactions suggest that a subset of the *GRD* genes encode proteins that function at the same golgi retention step and may act in concert with the clathrin heavy chain.

Haghighi, S., G. Johnson, A. Clapper, A. Stevens, A. Prapaisilp, and R. Madsen. Division of Neurosurgery, University of Missouri-Columbia. **FUNCTIONAL RECOVERY IN SPINAL CORD INJURY WITH 4-AMINOPYRIDINE AND METHYLPREDNISOLONE.** Exposure of axonal K⁺ channels after demyelination may contribute to blockage of action potentials across the injury site. A K⁺ channel blocker, 4-aminopyridine (4-AP), has been effective in restoring some sensory and motor impairment in incomplete spinal cord injury (SCI) patients. In this study, after a compression injury of 50 grams, a randomized treatment was initiated 3 weeks after the injury which was followed by daily administration of 4-AP at 2 mg/kg (n=8), 4 mg/kg (n=8), and 6 mg/kg(n=8) for 4 weeks. A group of methylprednisolone (MP)-treated (30 mg/kg, n=8) and non-treated animals (n=8) were included for comparison. The functional motor outcome was measured in each animal at regular time points up to 4 weeks post-treatment. The animals receiving 6 mg/kg developed generalized seizure and were excluded from the study. In the other groups, analysis of the behavioral outcome and neuro-pathological changes were essentially similar and did not show any significant effect of treatment. Our data indicate that daily administration of 4-AP, over 4 weeks of treatment period, lacks any significant effect on axonal recovery during chronic SCI in rats. One time bolus-administration of MP at 30 mg/kg also did not ensure a better functional outcome.

Hamm, B., C. Chatt, and G.D. Sells. Division of Science, Northeast Missouri State University. **CHARACTERIZING PROLINE OXIDASE FROM PLANT MITOCHONDRIA.** Previous studies have delineated that drought stress results in a logarithmic decrease in proline oxidase activity. This has been firmly established by Sells and Koppe (1981), K.J. Lee (1995) and by recent studies by Robinson and Whatley-Connell (1996). The cause of proline inhibition is unknown so we have set out to use electrophoresis to determine if there are any changes in succinic dehydrogenase and proline oxidase during stress. Thus far our attempts have been partially successful. There have been three bands for succinic dehydrogenase on agarose gels. Further modifications in techniques and strategies include altering the pH, using fresh mitochondria, and using acrylamide gels as well as agarose gels for isolating these two enzymes. Results obtained may provide a means to determine the nature of proline inhibition that occurs during drought stress.

Holtz, W.A., E. Martinez-Barajas, D.D. Randall. Department of Biochemistry, University of Missouri-Columbia. **ANALYSIS OF CARBOHYDRATE DISTRIBUTION IN TOMATO FRUIT.** Knowing how carbon entering a fruit as sucrose is distributed into glucose, fructose, Glucose-6-Phosphate (G6P), and starch is important in understanding carbon metabolism. This study approaches the question of sugar and starch accumulation in two parts. The first study plotted carbohydrate distribution during tomato fruit development. In the second study, plants were fed sugar solutions to observe the effect on carbohydrate distribution. Both studies involved harvesting tomatoes and measuring the levels of glucose, fructose, G6P, F6P, sucrose and starch

For the study of fruit development, most of the changes in sugars occurred rapidly during the period following pollination, with all the levels tapering off gradually as the fruit matured. For the study of the plants that were fed sugar solutions, there was a noticeable increase in the amount of accumulated starch for those plants fed glucose and fructose in the winter. Another major result was that for plants grown in the winter, starch levels were much higher while fructose levels were much lower than for fruit grown in the summer. These studies show that some seasonal aspect, probably temperature, has an impact on how carbohydrates are distributed in the fruit. Inhibition of fructokinase and starch synthesis due to high temperature would seem a plausible explanation for this seasonal change in carbon metabolism.

Ichikawa, S. and M. Golomb. Division of Biological Sciences, University of Missouri-Columbia. **GENOMIC ORGANIZATION AND EXPRESSION OF A CCAAT-BOX BINDING TRANSCRIPTION FACTOR HOMOLOGUE IN CAENORHABDITIS ELEGANS.** In humans, a CCAAT-box binding transcription factor (CBF) activates the transcription of growth-regulated gene(s)

and interacts with proteins involved in cancer such as p53 and adenovirus Ela (Wu, B. et al. 1992). We have found a homologus of CBF in the nematode worm *Caenorhabditis elegans* (provisionally named *cb1-1*) and analyzed its genomic organization and expression. A complete cDNA corresponding to *cb1-1* has been sequenced and shows extensive similarity to human CBF. Southern analysis indicates that *cb1-1* is a unique gene in *C. elegans*. We have mapped and partially sequenced the genomic DNAs for *cb1-1* and identified a possible promoter region. We are currently hybridizing cDNA probes to staged Northern blots in order to determine at what state(s) of development and dauer recovery *cb1-1* is expressed. Supported by Howard Hughes Medical Institute-Undergraduate Biological Sciences Education Initiative.

Klocke, P.S. Department of Science, Central Methodist College. THE EFFECTS OF FOLLICLE STIMULATING HORMONE (FSH) AND GONADATROPIC RELEASING HORMONE (GnRh) ON LITTER SIZE AND WEIGHTS IN THE GOLDEN HAMSTER. This study was designed to test the effectiveness of hormone therapy on reproduction. The hypothalamus naturally releases amounts of GnRH to stimulate the anterior pituitary to release a combination of FSH and luteinizing hormone (LH) into the blood stream. These two hormones have effect on follicle development and release. FSH and LH levels play a part in estrogen production and the feedback inhibition of these hormones. In the study, a combination therapy of 30µg/kg of FSH and 30µg/kg of GnRH was administered to one group of female hamsters by injection for four days before mating. Another group was given 30µg/kg of GnRH alone in the same manner. The combination therapy was found to be less effective in stimulating of follicle developemnt and release than the use of GnRH alone. The use of FSH negates the effect of the GnRH. The groups treated with GnRH alone had an increase in average litter size, while the group receiving the combination of hormones had only a slight increase in litter size.

Lawton, A., E. Kuzmin and K. Newton. Department of Biological Sciences, University of Missouri-Columbia. P2: AN UNSTABLE MITOCHONDRIAL GENOME IN MAIZE. Previous research has established that mutations in the mitochondrial genome (mtDNA) involving the essential function of ATP production can drastically alter the growth and development of all eukaryotes, including the maize plant. Typical maize mitochondrial genomes consist of subgenomic molecules which are consistently maintained through controlled recombination and replication events. An exceptionally unstable mitochondrial genotype, called P2, originated from a fertile popcorn line. The P2 defect is associated with highly variable phenotypes among sibling plants, including different types of leaf striping. The molecular difference among P2 plants have been analyzed by comparing mtDNA restriction and hybridization patterns. Our results suggest that mitochondrial variability in P2 plants could reflect changes in the recombination process giving rise to new subgenomic circles and/or alteration of the relative replication rates in pre-existing subgenomic circles. Supported by a Howard Hughes Undergraduate Research Fellowship.

Leighr, D.R. and D.B. Lubahn. Departments of Biochemistry and Child Health, University of Missouri-Columbia. TRINUCLEOTIDE REPEAT VARIATION BETWEEN DOMESTICUS MOUSE STRAINS: CORRELATION TO ESTROGEN RESPONSIVENESS. Previous research has established variation in estrogen responsiveness among mouse strains. In particular, 129 mouse strain uteri respond maximally to estrogen treatment after ovariectomy, when compared to C57BL/6 and other strains. In an attempt to explain this phenomenon, we hypothesized that the varying levels of responsiveness were due to a trinucleotide repeat within the estrogen receptor (ER) gene. This type of repeat has been found in several neurological diseases; these include fragile-X mental retardation, myotonic dystrophy, Huntington disease, schizophrenia and bipolar disorder. Sequence analysis of the mouse ER revealed a region rich in GCC or alanine repeats. further analysis of the human, rat, and chicken ER showed that the length of the repeat region varied between animal species. Through the use of polymerase chain reaction (PCR), we have shown repeat variation among mouse species but no variation among domestic mouse strains. We are currently developing a procedure to detect trinucleotide repeats anywhere in the genome and hope to link repeat regions with genetic diseases, such as the 'wobbly' phenotype in mice and autism.

Magai, R.M., P.S. Albert and D.L. Riddle. Division of Biological Sciences, University of Missouri-Columbia. POSITIONING OF *DAF-24* AND *DAF-25* IN THE *C. ELEGANS* DAUER FORMATION PATHWAY. Some *Caenorhabditis elegans* dauer formation (*daf*) genes are involved in both larval development and determination of adult life span. The dauer larva stage is a facultative dispersal stage formed in response to adverse environmental conditions. Mutations in genes involved in dauer larva development are divided into two main classes: dauer defective (*daf-d*) mutations that prevent dauer development and dauer-constitutive (*daf-c*) mutations that mandate entry into the dauer stage. A genetic pathway for dauer larva formation has been developed based upon dauer-constitutive and dauer-defective mutant interactions. The goal of this project is to better define the pathways for both dauer formation and adult life span. Two new dauer-constitutive genes, *daf-24 II* and *daf-25 I*, have been identified. Positioning these two genes in the dauer formation pathway was based on epistasis tests with dauer-defective mutations *daf-12* and *daf-16*. Previous work shows that dauer-constitutive genes that are suppressible by *daf-16* and not by *daf-12* double the adult life span. Conversely, dauer-constitutive genes that are suppressible by *daf-12* and not by *daf-16* do not affect adult life span. The experiments indicate that neither *daf-24* nor *daf-25* mutant life spans are extended, classifying these two genes with the majority of those previously studied. Consistent with this result, the *daf-24* mutation is not well suppressed by either *daf-12* or *daf-16*, separating it from the mutations known to increase life span. The *daf-24* gene is thought to be similar to *daf-19*, a dauer-constitutive gene that is positioned downstream of both *daf-16* and *daf-12*. epistatic relationships between the *daf-25* gene and the *daf-d* genes *daf-3*, *daf-5*, *daf-6*, *daf-10* were used to more specifically define the position of the *daf-25* gene and the dauer formation pathway. Data indicate that it is located in the upper branch between *daf-6* and the group of mutants containing *daf-10*. Further experiments are in progress to determine whether a life-extending allele of *daf-2*, a dauer-constitutive gene, affects the life spans of two dauer-constitutives on the upper branch.

McCarthy, Angela R., Sharyn K. Freyermuth and Joseph C. Polacco. Department of Biochemistry, University of Missouri-Columbia. ANALYSIS OF BACTERIAL AND PLANT UREASE ACCESSORY GENES. Pick-pigmented facultative methylotrophs (PPFMs) are bacteria associated with all green plants. Dr. Joseph Polacco's lab is interested in urease expression by PPFM's because these bacteria do not express urease when they colonize soybean plants which are mutated in specific plant urease genes. A goal of Dr. Polacco's research program is to determine whether plant genes can provide the function of some bacterial genes in production of bacterial urease. Most bacterial urease operons isolated to date consist of three structural genes and several accessory genes. *ureA*, *ureB*, and *ureC* code the urease structural subunits while the accessory genes are encoded by *ureD*, *ureE*, *ureF*, and *ureG*. In all bacterial urease operons isolated to date these accessory genes are necessary for the insertion of nickel into the apoenzyme product of the structural gene(s). To study the regulation of these accessory genes in PPFMs, protein extracts from PPFM cultures grown on urea and non-urea nitrogen sources were run over a nickel column in an attempt to isolate nickel binding proteins. Column fractions were examined by Western blotting with anti-*ureE* and anti-*ureG* from *Klebsiella* and anti-*ureE/G* from *Arabidopsis*.

Montgomery, J., M. Allen, T. Kuhn, A. McDowell, C. Sartors, G. O'Connor. Department of Biology, Rockhurst College. EFFECTS OF LOW CONCENTRATIONS OF PLANT EXTRACTS AND SYNTHETIC COMPOUNDS ON FEEDING IN *TENEBRIO*. Bioassays of plant extracts and synthetic compounds (concentration 800 ppm or greater) have been conducted in previous years to determine their potential as feeding deterrents for insects that normally feed on stored grain products. The current study measures at 400 ppm those compounds that were found to be effective at 800 ppm along with some additional compounds. This research was a cooperative effort among students in the Departments of Biology and Chemistry. Bioassays were conducted using larvae of *Tenebrio molitor* in both choice tests and weight gain tests. The choice tests consisted of the insects (40 per group) being given a choice between treated and untreated bran meal. Measures of feeding preferences were made, as

were time of pupation and insect death rate. The weight gain tests consisted of the insects (40 per group) raised on bran meal treated with the test substance. Weight changes were regularly measured for 6 weeks and compared with weight changes of insects on untreated food. Compounds which may undergo redox reactions via conjugate addition of amino and thiol groups of taste receptor proteins may have potential as insect feeding deterrents. We studied both the 1,4-benzoquinone and hydroquinone since they are potentially interconverted under environmental/biological conditions. Six 2-alkyl and 2,5-dialkyl derivatives were as active as the parent compounds but less toxic in choice tests at 800 ppm. One compound, 2-*tert*-butyl-hydroquinone showed moderate activity at 400 ppm.

Nguyen, H.G., J. Wall, R. English. Department of Biochemistry, University of Missouri-Columbia. ISOLATION OF THE *recA* GENE FROM *Desulfovibrio desulfuricans* BY COMPLEMENTATION OF AN *Escherichia coli* RecA-MUTANT. The RecA protein is known to play a central role in DNA repair and homologous recombination in bacteria. To isolate the *recA* gene from *Desulfovibrio desulfuricans*, a sulfate-reducing bacteria, its entire genomic DNA was cut with restriction enzymes, cloned into a cosmid, and introduced into *Escherichia coli* strain NM554, which is a RecA-mutant. Because the *recA* mutation disables repair of DNA damage caused by ultraviolet radiation, methyl-methane-sulfonate (MMS), or other similar reagents, the wildtype *recA* gene can be identified by the restoration of MMS resistance to a RecA-strain. A minimum concentration of 0.02% MMS was required to inhibit growth of the library strains which do not contain the *recA* gene. Colonies which show growth at this concentration of MMS will be further screened through UV irradiation to test for the *recA* phenotype. Once isolated further subcloning and screening will be used to obtain a smaller fragment for sequencing. The cloned gene will then be used to design a mutagenesis tool for creating RecA-derivatives of any *D. desulfuricans* G20 strain. Supported by Howard Hughes Medical Institute.

Paper, J. and C. Newlon. Department of Biology, William Jewell College. SMALL MAMMAL STUDIES IN AGRICULTURAL POLY-CULTURE RESEARCH PLOTS AND RESEEDED PRAIRIE AT THE LAND INSTITUTE, SALINA, KANSAS. The effect of the prairie conversion for use as agriculture fields has not only impacted the prairie ecosystem by changing the soil and plant composition in Kansas, but also the small mammal diversity on land used for agricultural purposes. The Land Institute is currently doing research on developing perennial poly-culture plots modeled after the native prairie that may eventually be an alternative agricultural source. Small mammal surveys were done on these research plots and an adjacent restored prairie area from 8-14-95 to 8-18-95 at The Land Institute. A total of 69 different animals were found on both areas representing 7 species. *Sigmodon hispidus* was dominant, representing 76.8% of total mammals captured. Other species included: *Mus musculus* (2.9%), *Onychomys leucogaster* (7.2%), *Spermophilus tridecemlineatus* (2.9%), *Reithrodontomys megalotis* (5.8%), *Microtus ochrogaster* (1.5%) and *Peromyscus maniculatus* (2.9%). All of the species except *Microtus ochrogaster* and *Spermophilus tridecemlineatus* were found in the research plots as well as the restored prairie. Further studies will need to be done to observe population trends of these mammals in the future. This study was supported by money from the William Jewell College Biology Department.

Philbrick, Kristin and A.D. McClellan. Department of Biological Sciences, University of Missouri-Columbia. REGENERATION OF ASCENDING SPINAL NEURONS IN LARVAL LAMPREY. Previous studies have shown that the central nervous system of the larval lamprey regenerates after spinal cord injury, leading to recovery of locomotor function. This study uses anatomical techniques to examine the time course of regeneration of spinal neurons with ascending axons in the lamprey. The spinal cords in the experimental groups were transected at 20% body length (BL), and the animals were allowed to recover for varying lengths of time. Horseradish peroxidase (HRP), a retrograde neuronal tracer, was used to label populations of neurons with axons ascending to 10% BL in both normal and spinal cord transected animals. A computer tracing and marking system was used to map the counts and location of HRP labeled cells. Labeled neurons are more numerous in the rostral spinal cord in both normal and spinal cord transected lamprey. After 2 and 4 weeks recover, there is little labeling below the transection. Recovery is more extensive after 8-16 weeks, but it is about half that after 32 weeks.

Total cell counts do not return to normal values even after 32 weeks' recovery. Dorsal cells, which are numerous in normal animals are present in much smaller numbers in spinal cord regenerated animals. When comparing only non-dorsal cells, counts in regenerated animals more closely approach those in normal animals after 32 weeks. Further studies will determine if the regenerated axons make functional synapses with the brain or other spinal neurons.

Rinne, J. and C. Newlon. Department of Biology, William Jewell College. SURVEY OF *ODOCOILEUS VIRGINIANUS* IN FLEMING PARK, JACKSON COUNTY, MO. Studies of white-tailed deer in the United States have shown an increase in suburban areas in recent years. High population levels lead to problems in suburban areas such as vehicle accidents and woody plant destruction. This study used the spotlight technique to survey the population of white-tailed deer in Fleming Park, Jackson Co., MO between 11-27-95 and 12-6-95. The numbers this year indicate a decrease of 28 deer per night compared to the survey done in 1993-1994 which showed an average of 80 deer per night. In the 1992-1993 survey there were 52 deer per night seen, while in 1995 an average of 51 deer per night were observed. The decrease between 1993-1994 and the 1995 survey may be due to a managed hunt on the area. Surveys such as this are useful to park officials as they develop strategies for maintaining deer populations.

Robinson, C.R., A. Whaley-Connell, and G.D. Sells. Department of Biology, Northeast Missouri State University. EFFECT OF DROUGHT ON ACTIVITY OF SELECTED ENZYMES OF MITOCHONDRIA ISOLATED FROM MAIZE SHOOTS. For some time it has been known that proline accumulates in droughted corn plants. Previous studies by Lee (1995) showed that the activity of the proline oxidase enzyme in 0.2 M sucrose solutions dropped 50% when corn seedlings were water stressed. It has been hypothesized that the decreased activity of the proline oxidase enzyme could be due to inhibition of the enzyme itself and/or decreased transport of proline to the enzyme. To test whether the build-up is due to transport differences, this study measured enzyme activity in varying sucrose concentrations in droughted and non-droughted corn seedlings. Thus far, the percent of proline oxidase activity compared to activity of succinic dehydrogenase (which is unaffected by drought) in non-water stressed maize shoots has been 53.1, 54.4, 62.4, and 58.6 percent in 0.05 M, 0.1M, 0.2 M, and 0.4 M sucrose solutions respectively. In contrast, the percent activity of proline oxidase from the droughted shoots when placed in lower sucrose concentrations (where the mitochondrial membrane is stretched) indicates that transport changes may be one factor that causes reduced proline oxidase activity in droughted plants. The possibility of enzyme inhibition cannot be fully ruled out; however, since there was still some proline oxidase activity in the droughted mitochondria when tested in the higher sucrose concentrations. Supported by Division of Science of Northeast Missouri State University.

Ronen, S. and H.C. Gerhardt. Division of Biological Sciences, University of Missouri-Columbia. HORMONE INDUCED RECEPTIVITY IN FEMALE GREY TREE FROGS. The project our lab is undertaking is to understand female mate choice preferences. The data for female responses is collected during the breeding season when females are captured in the field, and tested the next day. The problem with this method is that the research can only collect data during the breeding season. In order to extend the time available for data collection, different hormone treatments were tested. Females were treated with progesterone and prostaglandin to stimulate responsiveness. Using this method, we were able to collect data after the breeding season. However, the response of the females varied from 100% to no response. We are now systematically testing the efficacy of different hormone treatments.

Rothermich, M.T., G.D. Sells and J. Knopp. Department of Biology, Northeast Missouri State University. EVALUATION OF BACILLUS SPORES AS SURROGATE ORGANISMS FOR THE DETECTION OF *GIARDIA* CYSTS AND *CRYPTOSPORIDIUM* OOCYTES IN DRINKING WATER. *Giardia* and *Cryptosporidium* are water born parasites that cause serious illness and sometimes death in humans. The only currently approved method of detecting these organisms in drinking water is a direct

immunofluorescence method that is expensive, highly unreliable and takes 5-7 days to obtain results. In this study an alternate method, proposed by Rice et al from the EPA, was examined in which *Bacillus* spores which are smaller and more resistant to treatment, were used as surrogates. The procedure is straightforward, inexpensive and results are obtainable in 22 hours. Water from the Missouri and Mississippi Rivers was examined and found to have sufficient endogenous spore concentrations to provide a quantitative basis for evaluation of this method. Results suggests that *Bacillus* spore concentrations are highly correlated to turbidity, *E. coli* concentrations and heterotrophic plate counts in river water samples. However, the correlation was less in water sampled from farther into the treatment process, where the smaller, chlorine resistant, *Bacillus* spores were still found in measurable quantities. These preliminary results strongly indicate that this experimental method of examining water may provide a more discriminative test for evaluating the bacterial quality of treated water. Supported by Division of Science of Northeast Missouri State University and St. Louis City Water.

Shockley, F.W. Department of Biology, Westminster College. ROLE OF DOMINANT-SUBORDINATE RELATIONSHIPS IN SOCIETAL INFRASTRUCTURE IN MALE MADAGASCAR HISSING COCKROACHES (*GROMPHADORHINA PORTENTOSA*). Male *Gromphadorhina portentosa* exhibit a variety of behaviors used to establish a distinct social order. This social order can be expressed as a dominance hierarchy and can be determined using paired encounters. The strength of the hierarchy relies upon each insect's strict adherence to its specific rank. The purpose of this study was to ascertain how removal of the dominant males, termed α and β , would affect the hierarchy. In particular, an emphasis was placed on whether or not the removal of the dominant males caused a linear shift in rank or if there was rearrangement of the hierarchy. Ten males were placed in an isolated terrarium and allowed to set up a dominance hierarchy which was then determined using the results of paired encounters. Once established, the dominant males were removed and the hierarchy was tested again. After a 96 hour latency period, the hierarchy reestablished in such a way that the ranks before and after removal of the dominants showed no corelation (Spearman's ρ and Kendall's τ). In addition, the hierarchy reverted back to its previous arrangement after the dominant males were returned to the colony. It is believed that various individual behavioral characteristics play a more significant role in hierarchical establishment than previous social experience.

Springer, Nathan M., Sue Hum-Musser, Biology Department, Southeast Missouri State University; **Kenneth C. Gross,** United States Department of Agriculture, Agricultural Research Services, Horticultural Crops Quality Laboratory; and **David A. Starrett,** Biology Department, Southeast Missouri State University. PCR AMPLIFICATION AND CLONING OF AVOCADO α -GALACTOSIDASE. Large amounts of avocado fruit are lost every year due to premature ripening and related spoilage. Pectin solubilization and its effect on softening is an important aspect of the ripening process. Avocado α -galactosidase has been shown to solubilize pectin, a major component of fruit cell walls (De Veau, et al., 1993, *Physiologia Plantarum*). We are attempting to clone avocado α -galactosidase in an effort to determine its involvement in the ripening process. Heterologous degenerate oligonucleotide primers were constructed by using conserved regions of coffee (Zhu and Goldstein, 1994, Gene) and guar (Overbeeke et al., 1989, Plant Mol. Biol.) α -galactosidase genes. These primers were then used to PCR amplify avocado (*Persea americana* Mill. cv. Hass) cDNA. The resulting fragments were cloned into the pCR-Script plasmid vector (Stratagene, La Jolla, CA), characterized, and sequenced. The sequence revealed a high degree of homology with the coffee and guar alpha-galactosidase sequences. The inserts were then excised, purified, and labeled using a Genius System non-isotopic labeling kit (Boehringer-Mannheim, Indianapolis, IN). The labeled probes are being used to screen a cDNA avocado library constructed from ripening fruit. Positive plaques will be isolated, the insert subcloned, characterized and the sequence determined. This work will eventually allow for the construction of antisense fragments for α -galactosidase. These antisense constructs used alone and in conjunction with other antisense constructs will help to elucidate potential roles of α -galactosidase in ripening related events in avocado.

Subramanian, G., and T. Baskin. Department of Biological Sciences, University of Missouri-Columbia. EFFECTS OF GIBBERELLIN INHIBITORS ON ROOT MORPHOLOGY. Plant morphogenesis is regulated by growth regulators and hormones. The hormone gibberellin has recently been implicated in morphogenesis because studies have shown that morphology is altered when gibberellin synthesis is inhibited. However, these experiments have relied on inhibitors whose effects may not be specific. To examine the relation between gibberellin status and morphology, we compared the results of plants treated with inhibitors in the presence and absence of exogenous gibberellin. Five inhibitors that blocked gibberellin synthesis at different stages of the pathway were used. These inhibitors were ancymidol, paclobutrazol, tetcyclasis, uniconazole, prohexadione-CA. These experiments were conducted with 7-day old seedlings of the plant *Aradidopsis thaliana* which were transplanted onto agar containing known concentrations of each inhibitor. After a 2-day period root elongation and radial expansion were measured. All the inhibitors used induced morphological changes by slowing root elongation and by stimulating radial swelling. However, simultaneous application of any inhibitor and gibberellin was unable to restore normal elongation or morphology of the root. These results indicate that the morphological changes induced are side effects of the inhibitors rather than a result of their action of gibberellin synthesis.

Tritt, K. and P. Mahoney. Division of Biological Sciences, University of Missouri-Columbia. EFFECTS OF FAT MUTATION ON IMAGINAL DISC DEVELOPMENT IN DROSOPHILA. The absence of the fat gene produce in *Drosophila melanogaster* results in a post-larval lethal phenotype characterized by massive overgrowth of the imaginal discs. One approach to the study of this overgrowth is taken by monitoring the activity of genes responsible for the underlying developmental pattern of the tissue such as the *engrailed (en)*, *patched (ptc)* and *decapentaplegic (dpp)* loci in imaginal disc tissues of flies wild type for the *ft* locus as well as ones with the *ft^{st44}* mutation. This is accomplished through the use of a *lac Z* insertion that acts as an "enhancer trap" to track the gene activity. For observation of this activity, the discs were dissected from third instar larvae, partially fixed with 4% paraformaldehyde and incubated overnight with X-gal (5-bromo-4-chloro-3-indotyl-B-D-galactoside) in a water bath at 37°C. Following incubation, the discs were mounted on glass slides using 50/50 glycerol/PBS for subsequent viewing on the light microscope. All three patterns were disrupted with respect to the wild type, but the most significant difference was seen in the *dpp* pattern. The mechanism by which the wild type fat protein inhibits this overgrowth is as yet unknown. The goal of this study is a knowledge of this mechanism in an effort toward a better understanding of tumor suppression activities in general.

Vanover, M. and P.W. Gabrielson. Department of Biology, William Jewell College. EFFECT OF A WASTEWATER TREATMENT PLANT ON THE WATER QUALITY OF RUSH CREEK. The objective of this study was to examine the potential impact of the outflow from a wastewater treatment plant on the water quality of Rush Creek. The treatment plant became operational in December 1993. From April, 1994 through March, 1995, three sites upstream and three downstream from the treatment plant were monitored monthly for dissolved oxygen, biological oxygen demand, phosphates, nitrates, pH, water temperature, turbidity, and total solids and used to determine the water quality index (WQI) of Rush Creek. The average WQI at sites upstream (73), at the plant (70), and downstream (72) were all within the good range for water quality, indicating the treatment plant was effective. Phosphate levels increased at the plant site and tended to be high through the summer months at downstream sites. This study was partially supported by funds provided by the Missouri Academy of Science.

Wagner, D.J. Department of Biology, Missouri Western State College. INHIBITION OF JUGLONE ON GERMINATION AND GROWTH OF *HELIANTHUS ANNUUS*, THE COMMON SUNFLOWER. The purpose of the experiment was to examine interspecific allelopathic competition. The allelopathic effects of the Black Walnut on germination and growth of the Common Sunflower were studied. Over a four week period the Common Sunflower was exposed to various concentrations of juglone. Juglone

was crudely extracted from the husks of the Black Walnut fruit. Two control groups of (0%) were established along with seven experimental groups consisting of (1%), (10%), (50%), and (100%), respectively. One-hundred seeds per plot were planted and exposed to 24 hour fluorescent light over a four week period. The number of plants germinating per day were counted and the height in cm. of each plant measured. The study shows that although juglone inhibits the growth of the Common Sunflower, it has little effect on germination.

Wolf, W.W., W.J. Cox and M.R. Enochs. Department of Science, Central Methodist College. THE EFFECTS OF MULTIPLE STRESSES, CORTICOSTERONE, AND ACTH ON PLASMA AND ADRENAL CHOLESTEROL LEVELS IN RATS. Previous studies indicated an increase in plasma cholesterol levels with the introduction of multiple stresses and corticosterone injections. Our study further examines these factors as well as the effects of ACTH on plasma and adrenal cholesterol levels. Sprague-Dawley rats were divided into three groups (n=5). Group one (ACTH) was given a 20 μ g/kg rat injection of ACTH in saline once daily for five days. Group two (CORT) was given a 20mg/kg rat injection of corticosterone suspended in corn oil once daily for five days. Group three (SDS) was stressed once daily for five days by forced swimming in cold water to the point of exhaustion. In comparison of the plasma cholesterol levels, there was a 66% increase with the SDS rats and a 46% increase with the CORT rats, but a 37% decrease in the ACTH rats from pre-experimental values. The adrenal cholesterol levels showed a 8% increase with the SDS rats and a 47% increase with the CORT rats, but only a 2% decrease with the ACTH rats.

Chemistry/Geology Section

Armstrong, M., J. Lydon, S. Jurisson. Department of Chemistry, University of Missouri-Columbia. USES OF RADIOACTIVE GOLD COMPLEXES IN THE TREATMENT OF CANCER. Our research is the first of a multipart study into the potential of using radioactive Au(III) for treatment of cancer. The advantage of this work is that, if successful, this treatment would be cancer specific, rather than be useful only for selective types of cancer (i.e., ⁹⁰Sr for treatment of bone cancer). The radioisotope Au-199 is selected for its short half-life and for the emission of medium energy beta particles, making it ideal for the localized treatment of cancer with minimum damage to healthy cells. Our work focuses on using Schiff base ligands to stabilize Au(III). These ligands were selected for their hardness and because they are tetradentate. Specifically, recent studies have centered on the ligands Disalicylaldehyde ethylenediimine (Sal₂En) and salicylidenedyl 2-[4(5)-(thiomethyl)imidazolyl]ethylamine (N₂OS). These ligands, complexed with Au(III), are fully characterized by NMR, IR, UV-Vis, and x-ray crystal structure. Further, their stability in pH 7.4 phosphate solutions, as in reducing environments is analyzed. If these complexes are sufficiently stable, then studies will be initiated, to determine their likelihood for use as potential radiotherapeutic agents.

Beasley, T., T. Fite, M. Wiggins, H. Wilcox, S. Jones, K. Kuhler and R.N. Roy. Hoffman Department of Chemistry, Drury College. THERMODYNAMICS OF In/HCl(m₁) + In/Cl₃(m₂)/AgCl, Ag AT 25°C. The electromotive force measurements of the cell without liquid junction (A) was used to study In(s)/HCl(m₁) + InCl₃(m₂)/AgCl, Ag(A). The electromotive force measurements were investigated for solutions at constant ionic strengths in the range of 0.01 to 3 mole \cdot kg⁻¹ at 25°C. The mean activity coefficients of HCl in the mixtures were calculated using the Nernst equation. The standard potential of the Indium-Indic couple in solutions of Indium trichloride have been determined at 25°C.

Bice, J., P. Vann, W. Foard, S. Jordan, W. Good, J. Greer, R.N. Roy and L.N. Roy. Hoffman Department of Chemistry, Drury College. PHYSIOLOGICAL BUFFER "HEPES" AS A pH STANDARD IN 50 MASS % ETHYLENE GLYCOL-WATER MIXTURE AT SUB-ZERO TEMPERATURES. The values of pK₂ for biological buffers HEPES, N-2-Hydroxyethylpiperazine-N'-2-ethanesulfonic acid has been obtained in 50 mass % ethylene-glycol-water mixtures at 0°, -5°, -10°, -15° and -20°C from electromotive force measurements in cells using the emf cells without liquid junction of the type: Pt; H₂ (g, 1 atm) HEPES(m₁), Na HEPESate(m₂), NaCl (m₃) in 50 mass % Ethylene Glycol-

Water | AgCl; Ag. The pH values were derived from the experimental values of pK_2 . These buffer solutions of HEPES prove useful as secondary reference standards for the measurement of pH in ethylene glycol-water mixtures at subzero temperatures for cryopreservation of organs, tissues, muscles, etc., which are highly dependent on the pH of the bathing solution.

Carlsten, J., J. Thornsberry, A. Kilker, H. Hagerman, K. Journagan, R.N. Roy and L.N. Roy. Hoffman Department of Chemistry, Drury College. BUFFER STANDARDS OF 2-(N-Cyclohexylamino)Ethanesulfonic Acid ("CHES") FOR THE PHYSIOLOGICAL RANGE OF pH 6-8. The Zwitterionic compound 2-(N-Cyclohexylamino)ethanesulfonic acid, known as "CHES", is one of the series of buffer materials chosen by Good et al for their compatibility with biological media and their high buffer capacity in the pH range of physiological interest. Conventional pH values at temperatures at 25 and 37°C have been assigned to two buffer solutions composed of CHES and its sodium salt by the method used to establish the NBS primary pH standards. Cells without liquid junction were employed with hydrogen electrodes and silver-silver bromide electrodes, and the Bates-Guggenheim convention for the single ion activity coefficient was used. The compositions of the buffer solutions selected were 0.02m CHES + 0.02m sodium CHESate and 0.06 CHES + 0.06m sodium CHESate. The results will be compared with similar buffers.

Harmata, M. and T. Khasawinah. Department of Chemistry, University of Missouri-Columbia. SYNTHESIS OF NOVEL MOLECULAR CLEFTS. Molecular clefts are an interesting class of molecules which contain cavities and have many potential uses. Cleft-shaped molecules can behave like biological enzymes and bind to specific substrates to catalyze reactions. Molecular clefts also act as receptors and, therefore, are useful in binding to other molecules or ions. We are currently investigating the synthesis of sulfur analogs of a class of clefts called calixarenes. Due to solubility problems, the synthesis of the cleft has not been completed yet. This problem will be remedied by modifying the structure to make it more soluble and will be studied further. In addition, the synthesis of another class of compounds called benzodithiophenes are being pursued and will be studied for possible clathrate formation.

Kruger, A.J. and K.N. Carter Jr. Division of Science, Northeast Missouri State University. DEFINING VALUES OF THE OPERATING PARAMETERS OF THE WEIMER AND SMITH OSCILLATING REACTION. In the April 1994 edition of the *Journal of Chemical Education*, authors Jefferey J. Weimer and Wayne L. Smith describe an oscillating reaction useful in demonstrating the principals of mass and heat transport. The procedure described uses a heated platinum wire to catalyze the combustion of methanol. Some steps in the procedure lack details, and the authors imply the possible need for adjustment of the procedure to attain acceptable oscillating behavior. The purpose of this research is to define the values of the operating parameters so those wishing to demonstrate this reaction have the information to do so successfully and efficiently. This research investigates temperature, shape of flask, height of platinum wire from the surface of methanol, and the size of the flask's orifice. Times between oscillations are measured with a stopwatch to gather data on reproducibility, and randomness of the oscillations. Observations from adjustments made in the procedure are used to define the values of the operating parameters yielding oscillating behavior. Variances in the times between oscillations have been observed when conditions are altered.

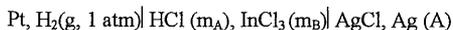
Martin, B.R. Department of Science, Northeast Missouri State University. SYNTHESIS DIRECTED TOWARDS A PORPHYRIN BASED MOLECULAR WIRE. As technology rushes towards miniaturization, the demand for smaller electronic components rises. Scientific advances now push this miniaturization to the molecular level. There have been numerous studies recently which have focused on the development of electrically conductive one-dimensional arrays which have been termed molecular wires. Organometallic polymers are ideal for this purpose due to inherent versatility in the design of organic frames coupled with the charge flow directing capability due to differing metal oxidation states.

This study has focused on the design of a molecular wire that is composed of porphyrin moieties. Porphyrin, composed of an organic ring surrounding a metal atom, should serve as an ideal building block for the design of a conductive polymer. This work is based on the stepwise building of porphyrin using dipyrromethanes. Through careful stepwise addition of pyrrole and aldehyde to 1,4-bisdipyrromethylbenzene, a phenyl bridged porphyrin dimer was synthesized. This is an exemplary reaction to show the utility of the dipyrromethane in molecular wire synthesis.

Niederschmidt, J., H. Dalsania, J. Kee, J. Coltharp, M. Norgren and K. Kuhler. Hoffman Department of Chemistry, Drury College. DISSOCIATION CONSTANTS OF *m*-NITROANILINIUM ION IN DMF-WATER MIXTURES AT 25°C BY SPECTROPHOTOMETRIC MEASUREMENTS. The dissociation constant of meta-nitroanilinium ion was studied in mixed solvent systems consisting of an aprotic organic solvent, dimethylformamide, and water. The pK_a of the weak acid *m*-nitroanilinium ion has been determined in solutions of varying concentrations of organic-aqueous solvents. Aqueous solvent mixtures of 10, 30, 50, 70, and 90 mass% *N,N*-dimethylformamide were studied. The *m*-nitroanilinium ion has previously been studied in a number of other organic aqueous solvent mixtures including aqueous solutions of 1,2-dimethoxyethane, acetone, tetrahydrofuran, dioxane, dimethylsulfoxide, sulfolane, and methanol. These results will be compared with those of other aqueous-organic mixtures.

Pearcy, A., D. Schmoll, J. Bice, R. Kulkarni, K. Kuhler and L. Roy, H. Hoffman Department of Chemistry, Drury College. SECOND-STAGE DISSOCIATION OF 3[*N,N*-bis(2-Hydroxyethyl)amino]-2-hydroxy-propane- sulfonic acid (DIPSO) IN WATER AT 298.15 K. The second thermodynamic dissociation constants of 3-[*N,N*-bis(2-Hydroxyethyl)-amino]-2-hydroxypropane- sulfonic acid (hereafter known as "DIPSO"), a useful secondary standard biochemical buffer within the pH range 6.6 to 7.4, have been determined from 278.15 to 328.15 K at intervals of 5 K (including 310.15 K), in water even though data are reported only at 298 K. E.m.f. measurements in cells without liquid junction (using hydrogen and silver+silver chloride electrode) were made. These results (obtained in water) are compared with those of compounds similar to DIPSO.

Wisner, D., D. Foster, P. Harris, A. McNabb, T. Beasley, T. Bedell, and L. Roy. Hoffman Department of Chemistry, Drury College. THE HCl + InCl₃ + H₂O SYSTEM AT 25°C. Electromotive force measurements of cell A without liquid junction have been used to study the HCl + InCl₃ mixed strong electrolyte system. The hydrogen and silver-silver chloride electrodes have been used in the cell:



The emf measurements were investigated for solutions at constant total ionic strengths ranging from 0.005 to 3.5 mol.kg⁻¹ and at a temperature of 25°C. Harned's empirical equations have been used to treat our experimental data. The mean activity coefficients of HCl in the mixtures were calculated using the Nernst equation. The validity of Harned's rule was tested.

Young, J.M. and K.N. Carter Jr. Division of Science, Northeast Missouri State University. COMPARISON OF NONPARAMETRIC CONFIDENCE INTERVALS FOR INTERSECTIONS OF PIECEWISE-LINEAR TITRATION CURVES. Establishing a statistical model for analysis can be a complex, error-prone process, which may throw away information. Nonparametric statistics, combined with the ability of computers to handle computationally intensive algorithms, may lessen the number of assumptions, such as normal distribution, necessary to build a model. These algorithms may also allow more data to be used, produce more accurate estimates, and uncover hidden patterns. Bootstrapping, a nonparametric method, is compared to standard parametric methods. Various methods to optimize efficiency and accuracy are discussed.

Geology Section

Chrisfield, R.A. Department of Geology and Geophysics, University of Missouri-Rolla. **COULD ARCHAEOPTERYX LITHOGRAPHICA FLY?** Compilation of information from numerous references indicates that considerable debate exists concerning the flight capabilities of *Archaeopteryx lithographica* and the origin of flight. *Archaeopteryx lithographica*, the oldest discovered "bird" fossil, represents the only known intermediate form between theropod dinosaurs and modern birds. Structurally, *Archaeopteryx* is both reptile-like and bird-like; it is a bipedal animal with four-toed hind legs, small feathered forelimbs, a toothed jaw, and a long feathered tail. Research has found the brain, pelvic girdle, and bone marrow to be caught in the act of evolution. Flight development is generally explained by either the arboreal theory (trees down) or the cursorial theory (ground up). The arboreal theory is supported by the occurrence of modern intermediate forms (flying squirrels), claw curvature, and wing contours. The cursorial theory is supported by aerodynamics, climbing skills, feather asymmetry, and other intermediate organisms (ostriches). This author favors the cursorial theory of flight origin, but is undecided concerning *Archaeopteryx lithographica*'s flying capabilities.

Harszy, D.A. Department of Geoscience, Southeast Missouri State University. **THE THEBES SANDSTONE: A POSSIBLE WESTERN ORIGINATING SEDIMENT IN THE ORDOVICIAN ILLINOIS BASIN, THEBES, ILLINOIS.** The Thebes Sandstone is a sandy-siltstone that marks this boundary between the Upper and Lower Maquokata Formation. It is located in the western Illinois Basin and stretches from the southern tip of Illinois up to St. Peters, MO. During the Ordovician, the Illinois Basin was a large epicontinental sea. The Taconic Orogeny was taking place east of the basin and thus the Ordovician sediment package is primarily from an Appalachian source. Westward thinning and grain size decrease infer that the Thebes Sandstone, a siltstone of undetermined depositional environment originated from the west side of the Illinois Basin. If it is indeed of western origin, then it is the only major Ordovician basin fill of this kind.

Huskey, A.R. Department of Geosciences, Southeast Missouri State University. **USING PALEOMAGNETISM TO DETERMINE MAGMA FLOW DIRECTION WITHIN THE SHEETED DIKE COMPLEX OF THE TROODOS OPHIOLITE, CYPRUS.** Research has found that paleomagnetism is a reliable tool to determine the direction of magma movement in the formation of oceanic crust. This study was conducted to determine whether magma flowed vertically or laterally through the sheeted dike complex of the Troodos ophiolite on the eastern Mediterranean island of Cyprus. A 120m section of road cut was mapped and cores were drilled from a representative sample of 14 dikes. At least five cores were extracted from each dike within five centimeters of the chilled margin; these cores were oriented using Brunton and sun compasses. Three dimensional susceptibility ellipsoids were created by measuring the anisotropy of magnetic susceptibility of each core. These ellipsoids are categorized by either oblate or prolate shapes which show magma flow direction. Maximum susceptibility (K_1) is illustrated for each dike on equal area plots as well as observed demagnetization measurements. Data appeared to show that the movement was predominantly in a vertical, upward direction for each of the 14 dikes.

Pope, J.P. Geology/Geography Department, Northwest Missouri State University. **MIDDLE AND LATE PENNSYLVANIAN CONODONT BIOSTRATIGRAPHY OF THE NORTHERN MIDCONTINENT IN IOWA AND MISSOURI.** At least 60 glacial-eustatic marine transgressive-regressive cycles are now recognized from the mid-Desmoinesian to the mid-Virgillian (Pennsylvanian) in the northern Midcontinent outcrop belt of Iowa and Missouri. Recognition of first, last, sole, or acme occurrences of biostratigraphically useful morphotypes of conodonts, from maximum transgressive deposits, has facilitated correlation of these cycles with cycles in Texas. Upper Desmoinesian cyclothems are characterized by different ratios of morphotypes of *Neognathodus* and *Idiognathodus*. Morphotypes of *Idioprioniodus* and *Gondolella* also occur. At the lower Missourian boundary

Neognathodus becomes extinct, and the interfal includes a nodose idiognathodid fauna with the first appearance of a streptognathodid morphotype, *Streptognathodus cancellosus*. The middle Missourian interval is marked at its base by the *S. gracilis* fauna and more regularly ornamented *Idiognathodus* morphotypes. In the base of the upper Missourian-mid-Virgilian interval a change to the *S. firmus*-*S. alekseevi* fauna occurs and *S. gracilis* disappears.

Shepard, L.M., J.D. Kendall, K.C. Clark and T.G. Plymate. Department of Geography, Geology, and Planning, Southwest Missouri State University. STRUCTURAL STATE OF THE K-FELDSPAR IN THE RHYOLITIC TUFFS AND RING PLUTON GRANITES OF THE ST. FRANCOIS MOUNTAINS OF SOUTHEASTERN MISSOURI. We have analyzed the structural state of the K-feldspar in ten samples of the rhyolitic ash flow tuffs and seventeen samples of the ring pluton granites exposed in the Proterozoic St. Francois Mountains of southeastern Missouri. We separated K-feldspar from each sample by density and determined the structural state parameter Z (defined to vary from 0 for perfectly disordered sanidine to 1 for perfectly ordered microcline) from unit cell refinements based on an average of 11 x-ray diffraction peaks per sample.

We found the K-feldspar to be highly ordered (microcline) for all rock units studied. For the ring pluton granites, the structural state parameter Z averaged 0.84 with a standard deviation of 0.03; for the phenocrysts in the volcanic rocks the mean was 0.80 with a standard deviation of 0.08; and for the matrix in the volcanic rocks the mean was 0.78 with a standard deviation of 0.11. We interpret the homogeneity of the K-feldspar structural state throughout the St. Francois Mountains and the unexpectedly high degree of structural order in the volcanic K-feldspars as further evidence for the pervasive hydrothermal event postulated to have affected this area subsequent to crystallization of the entire volcanic/plutonic complex.

Statler, Philip N., Tandra L. Eifert and John M. Holbrook. Department of Geosciences, Southeast Missouri State University. DECIPHERING THE ORIGIN OF LARGE BURROW STRUCTURES IN MAMMOTH CAVE NATIONAL PARK. Considerably large, well-preserved fossil burrows found in the Saint Louis Limestone Formation of Mammoth Cave's Logsdon River Passage are among the earliest known burrow structures exhibiting both a significant size and a complex interwoven behavior. This study focuses on the environment in which the burrows were produced, the patterns or orientations of the structures, and the type of organism which produced the structures. Data collected at this point indicates that there are several types of burrowing patterns which lie in different zones of stratigraphic thicknesses in this marine unit. In the lowermost portions, a star shaped pattern was encountered which proceeded to a coil shaped pattern as higher layers were reached. These burrow patterns are mostly horizontal in nature and exhibit a consistent y-shaped branching pattern. The structures closely resemble those of the *Thalassinoides*, made mostly by crustaceans, and could be related to a similar detrital feeding organism.

Zahner, H.M. and G.J. Cwick. Department of Geosciences, Southeast Missouri State University. GEOPROCESSING OF LANDSAT TM AND GEOSCIENCE DATA TO EVALUATE POTENTIAL COBALT AND OTHER TRACE ELEMENT CONTAMINATION IN MADISON COUNTY, MISSOURI. Previous geochemical assessments of the soil around Fredricktown have identified several sites having anomalous concentrations of cobalt and other heavy metals resulting from past mining activities. To ascertain the extent of such contamination and determine if remotely sensed satellite data would be useful for delineating these and possible other sites, an investigation was conducted using multitemporal Landsat Thematic Mapper (TM) data and ancillary geologic, geochemical, and soils information. Two TM digital images collected over the area during the summers of 1984 and 1988 were processed using band ratioing and principal components techniques to characterize the spectral signatures of the known contaminated soil sites. Products were input into a supervised classification algorithm to generate map output of the area. Digitized maps of geology, geochemistry, and soils were overlain onto the classified image in a spatially merged GIS database. Analysis was then conducted to denote if any correlations existed between the various data types and anomalous soil localities. Preliminary results show success in using these data to isolate areas of known contamination. Further

assessment, using change detection procedures, suggests that the areal extent of this contamination may have increased over the timeframe tested.

Physics/Engineering/Computer Science Section

Anson, B.L., D. Dawson, C. Shields. Department of Physics, University of Missouri-Rolla. CHAOTIC BEHAVIOR OF A BIPOLAR MOTOR. We have investigated the behavior of a rotatable magnet in a time-changing, linear, magnetic driving field. A simple differential equation describes this system; however, numerical solutions and laboratory observations reveal both periodic and non-periodic behavior. Past research has demonstrated that a variation of the driving field's amplitude causes the magnet's period of rotation to double at an exponentially increasing rate, until the magnet rotates non-periodically and unpredictably. Further increase of the driving field's amplitude restores the periodic motion and begins another period-doubling route to chaos. Detailed inspection of the chaotic regions show that the motor's behavior is never random, but never repeats.

Bach, J.D., K. Masterman, D. Dawson, R.D. DuBois. Physics Department, University of Missouri-Rolla. COMPUTER IMAGED ACOUSTICAL HOLOGRAPHY. Acoustic holographic patterns were measured for several simple objects and compared to mathematically predicted interference patterns. The acoustic interference patterns were generated by sound waves originating directly from a piezoelectric speaker driven at a frequency of 20.6 kHz and from the sound reflected from an object. The sound intensity difference, which depends upon the phase difference between the two waves, was recorded by scanning a condenser microphone in an X-Y plane. A lock-in amplifier and a computer were used to record the phase information. This method allows easy manipulation of the data, for example, background subtraction. By measuring the source-microphone, source-object and object-microphone distances, the phase difference of the signals were calculated and a theoretical model of the interference pattern was compared to the experimental data. The theoretical model successfully predicted the observed intensity variations as a function of X and Y.

Berliner, Matthew, R.A. Winholtz and Fred Ross. Research Reactor Center, University of Missouri-Columbia. A MODEL FOR DEPTH-PROFILING STRUCTURE IN SEMI-CRYSTALLINE POLYMERS. Semi-crystalline polymers exhibit sharp and distinct x-ray diffraction peaks from the bulk of the material, but this crystallinity seldom extends completely to the surface. Thus, the surface may have properties which differ significantly from those of the bulk. Grazing incidence x-ray methods intrinsically produce diffraction results in which the depth of penetration varies with the Bragg angle theta. In order to use the full diffraction pattern to measure structure vs. depth, we are faced with the problem of deconvoluting this theta dependence. Our model to test theta deconvolution uses neutron diffraction from an iron plate measured through successive layers of aluminum absorbers to simulate the effects of an amorphous surface layer. This experiment was performed in Bragg and grazing incidence geometries to provide maximum path length variation. Surface layers were simulated by 1 to 6 Al plates (5mm each) on the Fe surface. The results of deconvoluting the Fe neutron diffraction spectrum are presented.

Bouchard, C.M. and E.A.J.M. Offermann. Physics Division, CEBAF. A LEAST SQUARES CALIBRATION OF $H(e,e'p)$. A least squares fitting routine utilizing the $H(e,e'p)$ reaction was developed to calibrate two spectrometers at the Continuous Electron Beam Acceleration Facility. A He target is used because the proton is the lone nucleon, resulting in no nuclear binding energy and neglecting thermal motion, no pre-collision intranuclear momentum. Because the collision is elastic we are able to utilize both conservation of energy and momentum, providing four equations that govern the interaction. Experimental considerations suggest measurement of the magnitudes of momenta are the most likely source for error. Thus we have three "unknowns" and four equations. With this over

determined system we are in a position to utilize the method of least squares. The method must be capable of a simultaneous fitting of multiple correlated fitting functions. The development of the method will be briefly discussed. The routine was tested on a pre-existing database by assuming an errant energy measurement of 1 MeV. Four iterations were required to decrease X^2 by 7% while altering the magnitude of momenta values by several hundredths of one percent. A discussion of the method of least squares will be followed by a discussion of the kinematics of the collision, the development of X^2 for the system, and possibilities for increasing the routine's efficiency.

Callaway, M.B. and P. Miceli. Department of Physics and Astronomy, University of Missouri-Columbia. CHARACTERIZATION OF MATERIAL INTERFACES BY X-RAY REFLECTIVITY. The interfaces of material multilayers are studied to gain knowledge of thin film growth morphology as well as surface and interface structures. This information is essential to characterize materials, both for development of device technology and for fundamental study. X-rays are extremely useful in exploring the structure of materials on atomic length scales. Of specific interest is the behavior of interfaces between superconducting and non-superconducting media. A sample of superconducting material grown on a non-superconducting substrate was the object of x-ray reflectivity experiments to determine surface roughness and absorption. $K_{\alpha 1}$ x rays of wavelength 1.54 Å were scattered from the sample and intensity was plotted relative to the angle of reflection. Comparing the data to a mathematical model reveals surface thickness and roughness. These and similar data for various multilayers will be used in neutron reflectivity experiments detailing the penetration of applied magnetic fields into superconducting materials (London penetration).

Cerullo, M.A. and R.A. Mayanovic. Department of Physics and Astronomy, Southwest Missouri State University. EXAFS STUDIES OF THE COORDINATION AND POLYMERIZATION OF $ZnCl_2$. The purpose of this research was to study the coordination and polymerization of $ZnCl_2$ using Extended X-ray Absorption Fine Structure, or EXAFS. The absorption spectra were collected in the fluorescence mode for five different molar concentrations of $ZnCl_2$, 0.1 M, 1 M, 5 M, 10 M, and 11.4 M. The X-ray absorption measurements were made using a x-ray focusing beam line, equipped with a Li-drifted silicon detector, at the National Synchrotron Light source at Brookhaven National Laboratory. The local structure of the zinc ions was then determined from the absorption spectra using the University of Washington analysis package. We have for the first time directly observed evidence for the polymerization of the zinc complex species at the highest concentrations. The local polymerization structure was determined by fitting various models to our spectroscopic data.

Dennis, Darci, Department of Physics and Astronomy, Southwest Missouri State University. MODIFICATION OF TEFLON BY ION IMPLANTATION. Ion implantation of polymers for conduction purposes has been an area of research interest for sometime now. Polymers like Teflon have a broad range of applications due to excellent insulating properties. Through the process of ion implantation, microscopic damage is inflicted upon the surface of the material. This type of damage induces a form of electrical conduction known as variable range hopping (VRH). VRH conduction has been shown to follow two discrete models for conduction, the one-dimensional VRH and the three-dimensional VRH. The dominant conduction mechanism is determined by ion dose rate and follows a temperature dependence. The data presented will show the temperature dependence curves for ion-implanted Teflon in the ion dose range of 10^{16} ions/cm² to 10^{17} ions/cm². A "smart" package has been built and will be demonstrated as one possible application for the new semi-conductive Teflon.

Fischer, Keith D. Department of Computer Science, Southwest Missouri State University. WORLD WIDE WEB ROBOTS AND SEARCH ENGINES. The goal of our project was to implement Artificial Intelligence techniques to improve World Wide Web (WWW) search engine strategies. This led to the development of the "WWW Robot and Search Engine Frequently Asked Questions (FAQ)." This FAQ is a comprehensive layman's edition complete with sample code and interface. Included with the FAQ is a sample index building robot, a search engine, and a cgi-script. In the future we will implement functionality in our search engine to include that of a conceptual network.

Flenner, A.J., and B. DeFacio. Department of Physics and Astronomy, University of Missouri-Columbia. SIGNAL ANALYSIS IN BIOLOGICAL SYSTEMS USING STOCHASTIC RESONANCE. There are many effective techniques for analyzing signals when the signal to noise ratio is greater than one, such as Fourier analysis. When the signal to noise ratio falls below one signal analysis becomes a harder task due to the increased randomness of the signal. In this study stochastic resonance was used to detect signal, identify the signal's period, and distinguish between non-linear and linear systems with a signal to noise ratio of less than one. In order to detect the period of the function a threshold system was considered in which the threshold was higher than the noise level. A function was formed by giving the function a value of one when the signal plus the noise was greater than the threshold, and zero otherwise. The power spectrum of such a signal will show a maximum at certain values of the signal to noise ratio. The function was analyzed in order to detect the period of the underlying signal, and non-linear characteristics of the function. The period of the function was successively found to within 5% accuracy and differences in the function resulting from a non-linear signal were observed.

Flenner, E., G. Schupp, S. Thompson and W. Steiner. Department of Physics and Astronomy, University of Missouri-Columbia. MOSSBAUER QUASIELASTIC SCATTERING STUDIES ON LITHIUM HEPTA- GERMANATE. Measurements near the ferro-electric phase transition (283.5 K) on a single crystal of $\text{Li}_2\text{Ge}_7\text{O}_{15}$ have been made using the Quasielastic Gamma-ray Scattering instrument (QUEGS) at the Missouri University Research Reactor (MURR). This diffractometer utilizes Mossbauer photons from the 46.5-keV resonance in ^{183}W . Preliminary results indicate that within experimental uncertainties, the fraction of elastically scattered photons (within 1 μeV) exhibits no change as the crystal temperature is varied across the phase transition. These measurements were made at both the 0 0 10 and 6 1 2 Bragg reflections. Earlier work by *Krec et al*¹ showed a 15% decrease in the elastic scattering (within 2 neV) at the phase transition for the 0 0 10 reflection using the 14.4-keV Mossbauer photons from the 57-Fe. Further measurements are planned to better understand the difference noted above with earlier studies. Supported by NSF INT-9214230.

¹Krec, K., W. Steiner and M. Wada, *Acta Cryst.* A49 (1993) 198.

Hagerty, P.J. and P. Pfeifer. Department of Physics and Astronomy, University of Missouri-Columbia. THE ROPEWALK ALGORITHM: DIFFUSE TRANSPORT ON FRACTAL SURFACES. In many natural and industrial processes, the rate-limiting or performance-limiting step is the transport of a species to and across a surface. One complicating factor is that the expected increase in flux, as one increases the surface area, may be offset by the increase in screened, or inaccessible surface regions. For diffusive transport in two dimensions with diffusing particles that react on first impact with the surface, a celebrated theorem by Makarov says that the flux Φ scales with the diameter L of the surface as $\Phi \propto L^2$, regardless of the shape of the surface. When diffusing particles react only after many encounters with the surface, there is a net increase in flux due to the long diffusion time before reaction allowing particles to diffuse into the screened regions. Previous methods of computing Φ across the surface are solving the stationary diffusion equation under the stated boundary conditions with numerical approximations or with random walk simulations which require $O(L/l)^6$ operations. Our proposed ropewalk algorithm is an extremely efficient, $O((L/l)^2 \log(L/l))$ operations, method of solving the stationary diffusion equation. We compared the algorithm for circular and spherical surface geometries, for which the diffusion equation can be solved exactly. Computer programs were developed to implement the ropewalk algorithm for calculating Φ on self-similar, fractal surfaces. The ropewalk algorithm verified that the flux obeys a powerlaw of the transport parameters governed by the fractal dimension of the surface. The ropewalk algorithm is a powerful tool for solving a Laplacian field with mixed boundary conditions on an irregular surface. This project is supported by Howard Hughes and MURR REU.

Jackson, J.B., M.L. Foster, H.N. Ereifej, J.G. Story. Physics Department, University of Missouri-Rolla. INVERSE SHAKEUP SPECTRA OF DOUBLY EXCITED STATES OF BARIUM. Through a three laser excitation process, barium atoms are prepared in a high level doubly excited state, i.e., two electrons are excited. Normally, these doubly excited states, in this case the $6p_{1/2}nd$ states, decay by autoionization, a process in which one electron is ejected from the atom due to a collision between the two excited electrons. Some of the atoms decay via spontaneous emission of a photon from the $6p_{1/2}nd$ to $6sn'd$ singly excited state. The population distribution in the $6sn'd$ states shows evidence of inverse shakeup transitions between these two stages, i.e., $n' \neq n$. This novel transition involves a simultaneous change of state of both electrons. This experiment represents the first observation of shakeup due to spontaneous emission. Supported by University of Missouri Research Board and O.U.R.E.

Jeffries, J.H., J.K. Zuc and M.M. Craig. Department of Physics and Astronomy, Southwest Missouri State University. INSTABILITY OF KINETIC ROUGHENING IN SPUTTER-DEPOSITION GROWTH OF PLATINUM ON GLASS. We have studied the kinetic roughening in the growth of platinum (Pt) sputter-deposited on glass at room temperature using scanning tunneling microscopy (STM) for a film thickness range of 15 - 140 nm. Competing physical theories predict growing surface morphologies governed by different growth mechanisms, which are characterized by the roughness exponent (α), the interface growth exponent (β), and the average local slope (ρ). The growth exhibits an irregularly-growing mound morphology and displayed an instability with anomalous scaling behavior characterized by the $\sqrt{\ln(t)}$ dependence of the local slope, where t is the growth time, and also by $\alpha = 0.9$ and $\beta = 0.26$. These results support the conclusion that, under the given growth conditions, kinetic roughening during growth is consistent with a statistical model of linear diffusion dynamics.

Lee, W.T., O.I. Motrunich, B.E. Allman and S.A. Werner. Physics Department and Missouri University Research Reactor, University of Missouri-Columbia. NEUTRON POLARIZING DEVICE. New neutron polarizer has been built by neutron optics group for interferometry experiments and we are currently testing the device at beam port-C at MURR. The polarizer employs spin dependence of the neutron interaction with magnetic field and sharpness of Bragg reflection peak from a perfect crystal to spatially separate neutrons with opposite polarization. The polarizer consists of a magnetized iron prism (prism angle 60 deg) and an aluminum prism (angle 83 deg) placed between two perfectly parallel blades cut from a single silicon crystal perpendicular to the (220) direction. Neutron beam entering the apparatus is Bragg-reflected from one of the blades and directed through magnetically saturated iron prism where it is split into two beams with spins parallel and antiparallel to the magnetic field. Both beams are deflected but at different angles; estimated separation is 2.12 arc sec. The beams are then deflected back by the aluminum prism so that one of them is brought to the initial direction and is completely Bragg-reflected by the other blade to the output of the device. The other beam, being 2.12 arc sec off the center of Bragg reflection peak, is transmitted through the blade, as the acceptance width of the crystal is only 1.55 arc sec. Theoretical calculations show that the setup is very insensitive to relative misalignment of the prisms and errors in their angles. We are planning to use the device to perform Scalar Aharonov-Bohm effect experiment with polarized neutrons. Supported by the Physics Division of the NSF, grant number 9024608, and Howard Hughes Research Internship.

Miller, B.D. and J.E. Tansil. Department of Physics, Southeast Missouri State University. MODELING CLEAR-SKY SOLAR IRRADIANCE. We have experimentally measured the solar irradiance on a horizontal surface as a function of time during clear-sky days in Cape Girardeau, MO. An amplifier and interface were built and tested for digital storage of the analog signal from the Eppley model 8-48 pyranometer. The solar irradiance at the top of the atmosphere was used as an input for an atmospheric radiative transfer model in which the total irradiance was decomposed into beam and diffuse components, each depending on parameters determining atmospheric composition at the time of the measurement. By least-squares-fitting the theoretical model with the experimental data using computer software, we have found a simplified model that is dependent on temperature, relative humidity, and ozone concentration.

Moll, K.D. Department of Physics, University of Missouri-Rolla. APPLICATION OF COLLOCATION METHODS TO THE SCHRODINGER WAVE EQUATION. By solving a set of linear equations for a discretely sampled space, kinetic energy operators can be represented by matrixes - the operation of which is carried out by matrix multiplication. The Schrodinger equation can then be solved by determining the eigenvalues/eigenvectors of the matrix representation of the Hamiltonian. I will discuss the application of these methods, including boundary conditions, the advantages of Basis Splines over various other collocation methods investigated and numerical results supporting the validity of this method - including basic derivatives, the solutions of the radial Hydrogen problem, and time evolution of a wave packet. Due to memory limitations, we also have to employ methods such as Damped Relaxation and the Lanczos/Arnoldi algorithms. Very good approximations of the extreme eigenvalues of the full matrix can be calculated with a matrix of lower rank (~50%) and, for a symmetric Hamiltonian, tridiagonal. Supported by UMR OURE program.

Nugent, Allison and R.A. Mayanovic. Department of Physics and Astronomy, Southwest Missouri State University. ANALYSIS OF MOLECULAR STRUCTURE OF CuCl_2 AQUEOUS SOLUTIONS USING XAFS. The purpose of this study is to investigate the molecular structure occurring in various concentrations of copper (II) chloride solutions. In the course of this study, X-ray Absorption Fine Structure (XAFS) spectra were obtained for 0.1 M, 0.5 M, 1 M, 2 M, and 4 M CuCl_2 aqueous solutions, using the National Synchrotron Light Source at Brookhaven National Laboratory. The measurements were made in the fluorescence yield mode, using a Li-drifted, silicon diode detector. Analysis of the spectra is presently on going, to determine the structure and coordination of chlorine and oxygen ions surrounding the central copper ion. In particular, special attention is being paid to details of hydration in low concentrations and possibility of polymerization in high concentration copper (II) chloride solutions. This is being accomplished through the fitting of spectra based on theoretical models of the copper chlorocomplex, using the University of Washington analysis package.

Polly, C.P., J. Bach, and M. Wilson. Department of Physics, University of Missouri-Rolla. CONTAINMENT OF MACROSCOPIC PARTICLES IN A PAUL TRAP. Paul traps employ an oscillating electric field to generate a rotating saddle potential capable of confining charged particles. Traditionally these traps have been used in precision studies of electrons, ions and other atomic particles. In this study an inexpensive Paul trap was constructed and used to observe macroscopic dust particles (~30 μm in diameter). Particles trapped include anthracene ($\text{C}_{14}\text{H}_{10}$), flour, corn starch, and Pyrex microspheres. Trapped particles exhibit a 60 Hz oscillation with position-dependent amplitudes as large as 0.4 mm. By applying a DC voltage along the trap axis and observing the net displacement of the particle, the charge to mass ratio (Q/M) of trapped particles will be measured. Preliminary estimates indicate the net charge on individual particles to be approximately 10^5 elementary charges. Multiple trapped particles crystallize into stable geometric configurations. Amplitudes and positions were measured using a CCD camera, and particle interactions were recorded with a camcorder. The Paul trap described here provides a method for observing electrostatic interactions of charged macroscopic particles and quantitative determination of Q/M ratios. The Paul trap can also be used as an inexpensive, yet effective, apparatus for classroom demonstrations.

Pritchard, C.A., D.A. Hoff and J.N. Dahiya Department of Physics, Southeast Missouri State University. HIGH GAIN TUNED AMPLIFIER CIRCUITS FOR A MICROWAVE SPECTROMETER. Two different versions of a 31 KHz tuned amplifier are designed for a microwave spectrometer operating in the x-band of frequencies. The microwave signal is produced by a 2K25 reflex klystron and transmitted through waveguides to a cylindrical resonant cavity in TE_{011} mode. The principal voltages and mechanical tuning of the klystron are set to drive a signal frequency near the cavity resonance with two additional signals added for sweep and signal control. A sawtooth ramp voltage derived from the time base of an oscilloscope sweeps the klystron over the range of frequencies desired while simultaneously a chopper signal of 31 KHz is impressed upon the klystron repeller

electrode to produce an a.c. signal of that frequency at the detector. This arrangement allows for a synchronized sweep of frequency with the voltage scan of the oscilloscope. The 31 KHz signal enables high gain tuned amplifiers to be employed to detect the signal arriving at the radio frequency detector. One amplifier circuit has a wide band gain with center frequency around 31 KHz. The other circuit seems to be producing a very high gain with a little narrow bandwidth.

Schmid, T.J. Department of Physics and Astronomy, University of Missouri-Columbia. MODELING REFLECTIVITY CURVES OF ALLOY FILMS WITH SINUSOIDAL AND POWER-LAW COMPOSITION MODULATIONS. Neutron reflectometry is a tool used to study the structure of thin films and multilayers. Neutrons behave like x-rays and visible light in that they obey the laws of refraction and reflection. Although x-ray reflectivity can be used to study surfaces, neutrons have an advantage because they are affected by the atomic magnetic moments of the material. Also, because different isotopes have different indices of refraction for neutrons, unlike x-rays, the interface of two materials of similar structure can be studied by replacing an element by its isotope in one of the materials. This is especially done with polymers, where Deuterium can be substituted for Hydrogen. The reflectivity of neutrons at small angle of incidence is trivial to calculate for a small number of layers and straightforward to automate on a computer for more complex situations. This calculated reflectivity curve can then be compared to the raw data reflectivity curve, from which direct information about the composition profile of the multilayer sample can be deduced. In order to test the accuracy of molecular-beam deposition, our colleagues from Universite Leon Brillouin in Nancy, France created copper-titanium alloy films with both sinusoidal and power-law composition modulations. I have implemented FORTRAN code for insertion into existing data-fitting software to model these density profiles and will discuss how well the desired and actual profiles agree.

Weatherwax, John and Paul Miceli. Department of Physics, University of Missouri-Columbia. X-RAY STUDIES OF DEFECTS IN THIN FILMS. The project that I am working on, attempts to quantify X-ray data that was previously explained in a heuristic way. My project is to provide additional verification of those ideas. The basic idea is that we would like to attribute some X-ray data to the presence of defects in the crystals known as dislocations. Dislocations can arise throughout a crystal but in the system under study they arise when one crystal is grown on another, as in thin film semiconductors. It is from thin film semiconductors that the X-ray data has been gathered.

These dislocations can be modeled using an area of physics known as elasticity theory. Elasticity theory encompasses how a material will deform under stresses, and can predict what effect these dislocations will have within a crystal. This summer my mentor and I proposed two mathematical models for these dislocations. I solved them, by hand and using computer software. A third mathematical model involving boundary value problems was devised and solved last semester. This semester we are utilizing the results of our calculations to derive the expected X-ray line shapes. Once we have these shapes we can compare them with the data already obtained to determine how well our model for the dislocations matches experiment. We are currently performing those calculations, and hope to compare the two results soon.

Williamson, R.E. Department of Mathematics, Missouri Southern State College. AN INVESTIGATION INTO THE ANALYTIC AND ALGEBRAIC STRUCTURES OF USEFUL TRIANGLE TRANSFORMATIONS. The objective of the research centered on the transformation of a set of triangles into a workable, analytic, structure also containing the properties of an algebraic group. The research began with the solution of a problem in *The Stanford Mathematics Problem Book* by Polya, G and J. Kilpatrick, and pertained mainly to the extension of that problem. The original problem consisted of representing a set of triangles graphically as a function of the lengths of two sides of the triangle with the third side fixed at one unit. One of the primary goals of the research was to find an algebraic group structure on triangles, and although the structure was elusive, one was eventually found by mapping the set of triangles bijectively onto a standard group. Other areas of the research dealt with the analytic properties of the triangles under two separate transformations. Results of the research include: the discovery of the aforementioned group structure comparisons of the number of acute triangles

to the number of obtuse triangles, and graphical classifications of equal-area triangles, based on Heron's formula.

Behavioral and Social Sciences Section

Foley, Katy. Department of Geology and Geography, Northwest Missouri State University. **IMPACTS OF BASE CLOSURE ON THE REDISTRIBUTION OF MILITARY RETIREES.** Both the DoD and Congress recognize that closing military installations represent a prime opportunity to reduce defense spending. With a strength in excess of 1.3 million, military retirees represent an important element in the economics of a community. Current DoD impact statements do not address the possible impact that military retirees have on a region. The purpose of this research was to determine the level of military retirement migration following a base closure. Do military retirees living in a base's "catchment" area move or stay following a base closure? State level data were used to test hypotheses relating to an experiential base model. The data were analyzed using correlation, chi-square and statistical mapping techniques. The hypothesis that military retirees tend to retire near military installations was accepted at the 0.05 significance level. The results indicated a strong propensity for retirees to move when bases close. The data support the hypothesis that active duty experiences appear to be good predictors of retiree locations.

Lindstrom, J.A. and A.L. Otto. Division of Social Science, Northeast Missouri State University. **DECISIONMAKING IN THE WORKPLACE.** Our most significant disputes may occur at work. However, the best methods for resolving these disputes remain unclear. Previous research of workplace conflict indicates our perceptions are strongly influenced by organizational culture. This study experimentally tests the impact of three organizational culture variables shown in earlier survey research to influence perceptions of conflict. These variables reflect levels of communication, presence of formal systems for solving problems, and perceived rationality of relationships. Eighty subjects read one of eight workplace scenarios and completed a questionnaire to examine their perceptions of the conflict and possible methods for its resolution. Communication level affected subjects' judgements of the dispute the most. Subjects believing communications to be high were more likely to believe the dispute would be resolved, $[F(1.76)=13.79, p < 0.05]$, and that this would occur by talking informally with others involved, $F(1.76)=4.07, p < 0.05$. Further analysis will focus on how individuals decide that a conflict has occurred.

Revell, A., C. Hougham, K. Kerlin and S. Walkup. Department of Social Science, Northeast Missouri State University. **MOTHER-CHILD INTERACTIONS: AN ASSESSMENT OF ATTITUDES TOWARD DIFFERING TEACHING STYLES.** In the third year of a three part investigation, experimenters are currently examining mother's and their 8-9 year-old children's perceptions of differing teaching styles, based in part on the theories of Albert Bandura (modeling) and Lev Vygotsky (contingent interactions). Early parts of the study were spent developing videotaped segments depicting modeling and contingent teaching styles with age appropriate learners and easy or hard tasks. Currently, experimenters are recruiting and collecting data from 40 mother-child dyads to examine their behaviors and interaction styles during free play activities and experimenter specified tasks. In addition, participants are rating videotaped teacher-learner interactions based upon their personal attitudes toward those styles. Preliminary data analysis will be briefly discussed.

Tamerius, Sharon. Department of Geology and Geography, Northwest Missouri State University. **THE RELATIONSHIP BETWEEN CHURCH ATTENDANCE AND SELECTED SOCIO-ECONOMIC FACTORS: A SPATIAL ANALYSIS.** The objective of this study was to determine if there is a significant relationship between church attendance and personal income, education, ethnicity, unemployment, divorce rates, alcohol abuse, and violent crimes in the U.S. between 1980 and 1990. The

observation units are the 50 states of the United States. Empirically, there appears to be an inverse relationship between the decline of religion as expressed by church attendance and the increase of negative socio-economic indices. Hypotheses were formed about each relationship and tested by analyzing univariate statistics such as measures of central tendency, measures of shape, and measures of deviation; by analyzing histograms of the frequencies of observations of each variable; by performing a t-test analysis on each ratio scaled variable with respect to the nominal scaled variable, education; and by performing a correlation analysis on the relationship between all of the variables. Conclusions reached by this study show that, at a 0.05 significance level, there was no significant relationship between church attendance and ethnicity, unemployment, alcohol abuse, and violent crime. However, there is a significant positive relationship between church attendance and per capita income and education. There was a negative relationship between church attendance and divorce rates.

Wheelehon, J.R., R.S. Oehring and A.L. Otto. Division of Social Science, Northeast Missouri State University. MEDIA EFFECTS ON PERCEPTIONS OF RAPE VICTIMS. Television movies frequently show women as victims. Research indicates that these films raise empathy. Recently, however, there have been numerous films which depict women as perpetrators (WP), rather than victims of violence (WV). This study explores whether WP films negate positive effects of WV films and possibly produce strong negative reactions against female victims in individuals viewing films of both types. Subjects were randomly assigned to one of two experimental groups. Group 1 viewed a WV film, then a WP film, and finally a videotaped rape trial. Group 2 viewed the WP film followed by the trial. Preliminary results indicate that Group 1 subjects were less upset by the WP film, $F(1,10) = 5.57$, $p < 0.05$, believed the rape victim suffered less physical harm, $F(1,10) = 4.18$, $p < 0.10$, and, most importantly, believed the victim deserved to be raped $F(1,10) = 3.43$, $p < 0.10$. Our results support the idea that media depictions of crime victims pose a potential problem to the courts.

Wong, Alexander. Department of Geology and Geography, Northwest Missouri State University. GEOGRAPHIC PATTERNS AND PROCESSES OF LOTTERY SALES IN MISSOURI COUNTIES, 1993. Lotteries have played a very important role in society throughout history. The early Babylon Empire used lotteries to provide funding for legal and religious encumbrances. In modern times, governments also used lottery funds for general revenue and other special funding needs. In 1993, the Missouri lottery had record sales of \$283 million which provided the state with \$80 million in revenue. This research examined the relationship between scratcher ticket sales, by county, in Missouri for 1993 and the spatial variables: income; education; age; poverty level; and unemployment. Difference of means and correlation analyses revealed an inverse relationship between education, income and lottery sales. The results suggest that lottery expenditures are higher in those counties with less discretionary income.

**TRANSACTIONS OF
THE MISSOURI ACADEMY
OF SCIENCE**



Vol. 30, 1996

About the Academy

Scientists of the State of Missouri organized in 1934 to form the Missouri Academy of Science. By April 6, 1934, a Constitution and By-Laws were prepared and on August 14, 1934, the organization was incorporated.

The purposes of this Academy were presented in the fourth "article of agreement" as follows:

"This corporation is organized, not for profit but for the purposes of promoting the increase and the diffusion of scientific spirit, and of promoting cooperation between the scientific interests of Missouri. It proposes to accomplish these purposes:

- a. By holding meetings for the presentation of scientific papers embodying the results of original research, teaching experience, or other information of scientific interest.
- b. By fostering public interest in scientific matters, through open meetings, press releases and in such other ways as seem feasible.
- c. By encouraging local scientific organizations in every possible way.
- d. By promoting acquaintance in harmonious relationships between scientists in Missouri, and among all who are interested in science.
- e. By supplying, so far as finances permit, a medium for the publication of results of original work, particularly those of special interest in this state.
- f. By concerning itself with legislation on scientific matters, and providing opportunity for discussion of such legislation.
- g. By working in any and all other ways which may prove feasible, for the advancement of science in Missouri."

The Academy held its organizational meeting on April 13-14, 1934, with 250 people attending. At the December, 1934, meeting, more than 400 people registered and by May, 1935, there were approximately 750 members of the Academy. Statewide interest at a high level continued until activities made necessary by World War II caused disruption of Academy affairs except for some activity in the College Section.

Post-war revival of Academy activities started at a meeting on April 20, 1963, at Drury College. From the group of twelve persons who initiated the reactivation of the Academy in 1963, the membership has grown steadily to more than 800. Activities of the Academy have expanded to include the awarding of modest grants for projects proposed by high school and college students, and to sponsor the establishment of a Junior Academy of Science.

Since its re-activation in 1963, the Missouri Academy of Science has regularly held annual meetings at 16 different sites around the state. The refereed publication, the *Transactions of the Missouri Academy of Science*, has been published consistently since 1967. Six Occasional Papers have also been released.

Presently, 49 colleges and universities around the State of Missouri hold an Institutional Membership status. Many industries and other private businesses are supporting the Academy with Corporate Memberships.

Membership into the Academy is a year-round opportunity for everyone and runs from January 1 to December 31. Benefits include four quarterly *Bulletins*, one annual *Transactions*, and annual meeting lower pre-registration fee.

The Missouri Academy of Science is a non-profit organization and is supported solely by membership dues and donations. That is why we appreciate each new member and the current members who renew so faithfully each year. And it is because of their interest that the Academy continues its success as a fine scientific organization.

Information for Authors

Manuscripts

- Editorial Policy.* Authors must pay \$25.00 per printed page for publication costs. *Transactions* publishes several types of original contributions from the disciplines within the Academy: research papers, research notes, reviews, and annotated bibliographies. Manuscripts must be authored or co-authored by a member of the Academy. Each manuscript is subject to peer review. The Editor has final authority for acceptance or rejection. Manuscripts should be submitted prior to May 15 to the Academy Business Office:

Missouri Academy of Science
Attn: Nancy Shaddy
TSU, 100 E. Normal Street
Kirksville, MO 63501-4221
- Manuscript Preparation.* Type all material double spaced, on one side of standard sized bond paper. Submit 4 copies of the manuscript with illustrations for review purposes. Retain the original typescript and illustrations in your files. If accepted for publication, the final copy of the text and original art work will be requested. Each paper must include an informative abstract which records succinctly the essential findings, followed by a short list of key words for abstracting purposes. Each table must be typed on a separate page and be suitable for direct reproduction. Number tables consecutively and provide a short title at the top of each page. All illustrations must be high contrast black and white and reproducible. Handwritten or typewritten lettering or symbols are normally not acceptable. The manuscript is to be assembled in the following order: title, authors' names and affiliations, abstract, key words, text, acknowledgments, literature cited, tables, figure legends, figures. Number all pages. Authors should refer to current *Transactions* and a style manual appropriate to the discipline for details on style, format, and citation of references. Use the common and binomial Latin name of an organism when first mentioned. Subsequently the genus or common name may be used. Names of taxa should be underlined. Names of two or three possible reviewers should be supplied in a cover letter.

Abstracts for Annual Meeting:

- Editorial Policy.* Authors must pay \$10 per abstract for publication costs. Abstracts are to be submitted to the appropriate section chairperson by January 31 for the Senior Division and March 1 for the Collegiate Division of the year of the meeting.
- Abstract Preparation.* Type the abstract as one single-spaced paragraph within a 6 1/2 x 3 inch space using a fresh ribbon. Type the name of the author(s), not underlined, and the affiliated institution, using appropriate capital and lower case letters. If co-authors have different institutional affiliations follow each author's name with their affiliation. Type the title in all capital letters. Continue the paragraph with the main body of the text. Underline generic and specific names. Acknowledgment of support may be included as the last sentence of the text.