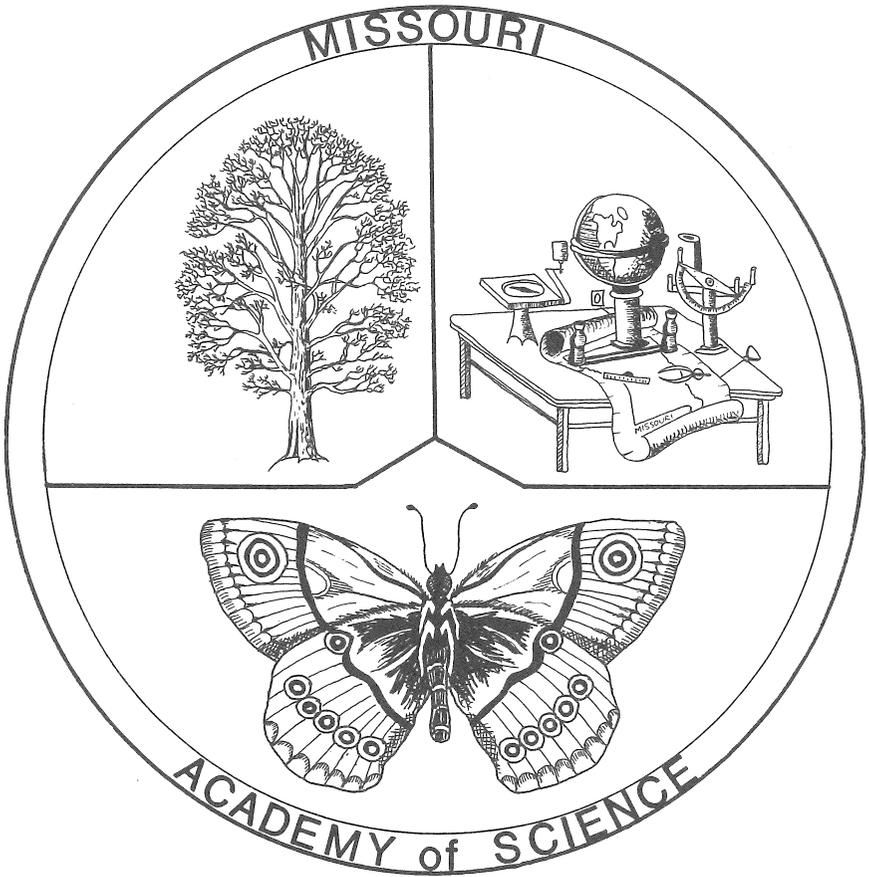


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Vol. 18, 1984

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Reaction of Soybean Cultivars to *Macrophomina phaseolina* as Seedlings in the Growth Chamber and Field¹

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Abstract: The reaction of seedlings of 14 soybean cultivars to *Macrophomina phaseolina* was assessed under suitable growth chamber conditions in an attempt to identify superior genotypes. The growth response of soybean cultivars to fungal attack by this soilborne pathogen varies with inoculum density. Cultivar responses in plant height, root volume and root and shoot weight ranged from stimulation in Dunfield to losses of 82-93% in Williams. Although the extent of growth changes for a given cultivar varied from 1 experiment to another, its relative position among tested cultivars remained essentially the same. Four susceptible cultivars, when tested in the field, became infected at a similar rate. These data suggest that growth responses of seedlings to infection by *M. phaseolina* may be useful in evaluating resistance to the charcoal rot disease.

Key Words: Charcoal rot, resistance, soilborne

Introduction

Charcoal rot disease, caused by the soilborne fungus *Macrophomina phaseolina* (Tassi) Goid., is one of the most serious diseases of soybeans (*Glycine max* (L.) Merr.) in the southern half of the United States (Wyllie 1974). In Missouri, over 25% of commercial fields sown to soybeans in 1981 harbored populations of the fungus (Wyllie and McKelvey 1983) capable of causing measurable yield losses (Short et al. 1980). Remaining fields also harbored the fungus, but at lower levels. Major increases in populations of the fungus can be expected with continued use of corn-soybean or soybean-soybean rotations (Short et al. 1978, 1980) combined with the indiscriminant use of soybean cultivars that are grown without regard to their response to attack by this organism. This study reports the result of screening various cultivars of soybean seedlings for their response to charcoal rot using growth chamber and field techniques.

¹Contribution of the Missouri Agricultural Experiment Station Scientific Journal Series No. 9626.

Materials and Methods

Fourteen cultivars of soybean seedlings were screened for their response to charcoal rot using the following growth chamber techniques. Seed was sown in vermiculite infested with *M. phaseolina*. The non-inoculated controls consisted of vermiculite mixed with autoclaved inoculum. Plant height, root volume and weight, and shoot weight were measured to determine the influence of this soilborne pathogen.

Inoculum was prepared by culturing *M. phaseolina* in potato dextrose broth (PDB) (50 ml PDB/250 ml flask) in darkness at 33 C for 20-23 days. Mats of mycelia were washed in sterile distilled water (3X) and air-dried. Sclerotia in each mat were broken apart with a spatula, suspended in 10 ml of 2% sucrose solution for 2 days at 33 C, diluted to a volume of 250 ml with sterile distilled water and then blended at slow speed for 15 seconds in a Waring blender. Contents from 1 flask were thoroughly mixed with enough sterile vermiculite (1550 cc) to fill a sterile clay pot. Prepared pots were covered with foil and incubated in the growth chamber for 2-3 days before planting. In 1 experiment the inoculum density was varied so that only $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$ and $\frac{1}{16}$ of the inoculum produced per flask was added to each pot of vermiculite.

The number of propagules added to the vermiculite was determined by diluting a known volume of the blended inoculum in 0.2% sterile water agar and plating aliquots on chloroneb-mercuric chloride-rose bengal agar (CMRA) a semiselective medium for *M. phaseolina* (Meyer et al. 1974). Inoculated plates were incubated in the dark at 33 C for 1 week then examined for colonies of *M. phaseolina*.

Only undamaged and nondiseased certified seeds were used (seed of PI 92-694 was not certified), and these were surface-sterilized prior to use (0.5% NaOCl for 60 seconds followed by 3 rinses in sterile distilled water and air-drying). Seeds were planted 4-5 to a pot 2.5 cm beneath the surface. Pots were watered daily after planting with 250 ml of either Hoagland's solution (Hoagland and Arnon 1950) or distilled water. Hoagland's solution was used every other day for the first week and thereafter every seventh day. Excess liquid drained from the pots. Two or 3 replicate pots were used per treatment for every cultivar tested. To better determine the effect of *M. phaseolina* on seedling emergence, seeds of Calland and Williams were planted into infested and noninfested vermiculite contained in flats (equivalent of 7 pots of vermiculite per flat; 200 seeds per flat). All conditions were the same as for the pot experiment except that the volume of the daily watering solution was increased 7-fold.

Growth chamber conditions were as follows: temperature-day (15 hr) 29.5 C; night (9 hr) 24 C; photoperiod-15 hr, fluorescent plus incandescent light at 200 ft.-c.; relative humidity - above 50%. Plant height was measured from the surface of the vermiculite to the growing point. Vermiculite was carefully washed from the plants 23-24 days after sowing the seed. Root volume was measured by blotting the roots (from the vermiculite line down) of individual seedlings with paper toweling to remove excess moisture, then submerging them in a partially filled graduated cylinder and recording the increase in volume. Roots and shoots were air-dried at 22 C until a constant weight was achieved for weight determination.

The incidence of charcoal rot was determined for 4 cultivars planted in naturally infested soil on the UMC-Bradford Agronomy Farm near Columbia. Plants (10/cultivar) were carefully dug at various times after planting (May 13). The roots were thoroughly washed in tap water, surface disinfested with 0.5% NaOCl for 60 seconds and rinsed in sterile distilled water. Primary and secondary roots of each plant were cut into segments 5-10 mm long. Segments of the entire primary root and 20 randomly selected secondary root segments were plated on CMRA, incubated and examined as described above.

Results

Growth response of soybean seedlings to fungal attack by this pathogen varies with inoculum density. However, it appears that the inoculum produced in 1 flask is 2-4 times the amount of inoculum needed to produce the maximum response from the 2 test cultivars, Adelphia and Calland (Table 1). For example,

Table 1. Effect of inoculum density on the response of seedling growth to *Macrophomina phaseolina*.

Cultivar	Inoculum density (propagules/cc)	% Change ^z			
		Plant height ^y	Root volume ^x	Root weight ^{xw}	Shoot weight ^{xw}
Adelphia	856 ^v	-78.5	-70.9	-72.8	-68.3
	428	-74.8	-66.7	-67.1	-60.5
	214	-55.2	-61.9	-65.6	-59.2
	107	-41.9	-32.9	-51.4	-39.2
	54	-62.6	-35.8	-43.5	-44.6
Calland	856	-82.5	-58.4	-63.9	-76.2
	428	-72.0	-51.4	-58.8	-56.8
	214	-76.5	-57.1	-52.3	-66.5
	107	-58.2	-37.2	-35.4	-41.1
	54	-42.7	-28.0	-11.9	-23.1

^z100% (inoculated value/control value - 1).

^yBased on plant height 15 days after sowing seed.

^xRoot and shoot data taken 23 days after sowing seed.

^wAir-dried weight.

^v856 propagules/cc = inoculum produced in one flask of PDB mixed with 1550 cc of sterile vermiculite. Inoculum density at time inoculum added to vermiculite.

the root volume for both cultivars did not change significantly when the inoculum density was between 214 and 856 propagules/cc of vermiculite.

When the reaction of 12 cultivars was compared (Table 2), both Adelphia and Calland were very susceptible, with Williams being the most susceptible cultivar tested. All 3 of these cultivars exhibited height reduction of more than 75%. By comparison, height of the Dunfield plants, the most resistant cultivar tested, was reduced less than 10%. *M. phaseolina* actually stimulated root and

Table 2. Seedling growth response of different soybean cultivars to *Macrophomina phaseolina*.

Cultivar	% Change ^z								
	Plant height ^y	rank	Root volume ^x	rank	Root weight ^{xw}	rank	Shoot weight ^{xw}	rank	Overall rank
Dunfield	- 8.3	(1)	+26.7	(1)	+104.7	(1)	+37.8	(1)	1
Mukden	-45.7	(3)	+25.1	(2)	+ 1.1	(2)	-19.6	(3)	2
PI 92-694	-29.4	(2)	+ 7.4	(4)	- 12.9	(4)	-26.7	(4)	3
AK. (Harrow)	-49.1	(5)	+ 7.9	(3)	- 1.0	(3)	-38.5	(6)	4
Mandarin	-47.4	(4)	-38.7	(6)	- 22.4	(6)	-37.8	(5)	5
Beeson	-79.7	(10)	- 4.7	(5)	- 15.3	(5)	-16.5	(2)	6
Richland	-69.6	(7)	-55.9	(8)	- 63.6	(7)	-60.8	(8)	7
Cutler	-57.7	(6)	-72.0	(11)	- 67.5	(9)	-56.0	(7)	8
Amsoy-71	-73.0	(8)	-48.3	(7)	- 66.9	(10)	-73.2	(10)	9
Adelphia	-78.5	(9)	-70.9	(10)	- 72.8	(11)	-68.3	(9)	10
Calland	-82.5	(12)	-58.4	(9)	- 63.9	(8)	-76.2	(11)	11
Williams	-82.4	(11)	-90.7	(12)	- 93.4	(12)	-87.6	(12)	12

^z100% (inoculated value/control value - 1).

^yBased on height taken 15 days after sowing seed.

^xRoot and shoot data taken 23 days after sowing seed.

^wAir-dried weight.

shoot growth in this cultivar as measured by weight change. The extent of growth changes for a given cultivar varied from experiment to experiment, but the relative position of the cultivar remained essentially the same. This can be seen by comparing responses of the cultivars Mandarin, Adelphia and Calland shown in Table 3 with their responses already shown in Table 2. The 4 cultivars

Table 3. Effect of *Macrophomina phaseolina* on seedling growth of 5 soybean cultivars.

Cultivar	Plant height ^z	Root volume ^y	Root weight ^{xy}
Mandarin	-29.5	-12.6	-10.5
Hill	-47.1	-31.7	-33.3
Adelphia	-49.2	-39.4	-38.5
Calland	-75.2	-56.5	-45.7
Clark	-71.5	-63.7	-53.2

^zBased on plant height 14 days after sowing seed.

^yRoot data taken 24 days after sowing seed.

^xAir-dried weight.

Amsoy-71, Calland, Clark and Williams were all very susceptible to charcoal rot. Roots of these cultivars became infected at nearly the same rate when planted in naturally infested soil (Fig. 1).

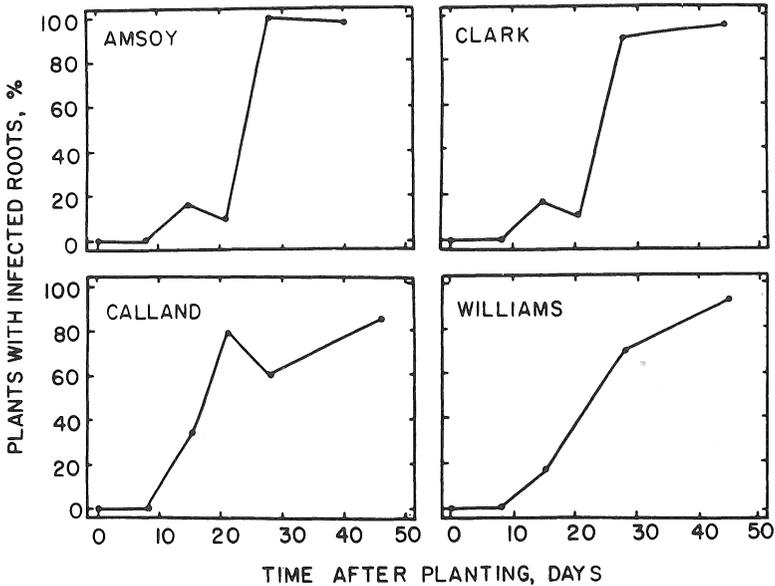


Fig. 1. Incidence of charcoal rot on 4 soybean cultivars at various times after planting in naturally infested soil on the UMC-Bradford Agronomy Farm. Planted 13 May 1974.

Discussion

Varietal reactions of soybean to charcoal rot caused by *M. phaseolina* apparently result from polygenic mechanisms, although such investigations have not been documented. In part, the difficulty in selecting superior soybean genotypes may reside with the nature of the biology and infection cycle of the pathogen within the soybean plant. Symptom expression and signs of the fungus, are normally not seen in this disease until late in the growing season (near flowering and pod fill) when plants are nearing maturity or when they are rapidly senescing. At this time only the saprophytic cycle of the fungus is observed. The pathogen infects the plant within the first few days to weeks in the field (Fig. 1) and continues to invade and colonize tissue throughout the remainder of the growing season. If plant selections are attempted late in the season based on the relative number of microsclerotia which are present in the tissue, little genetic gain can be made.

In previous studies, no significant differences were found in the number of *M. phaseolina* propagules in the roots of 10 soybean cultivars 8 weeks after

planting in naturally infested field plots (Moustafa 1976, Moustafa and Wyllie 1976). After 16 weeks the propagule level increased markedly and significant differences between cultivars emerged.

In our studies the cultivar Williams was the most susceptible cultivar tested. Williams constitutes 80-90% of commercial acreage grown to soybeans in northern Missouri. We know that at least 25% of the fields harbor populations of *M. phaseolina* capable of causing yield losses (Wyllie, unpublished data). Yields from commercial plantings of Williams have gradually declined the past 3-4 years according to our extension agronomist. Our studies suggest that this decline is more than coincidental. Field studies will be done to test whether the loss in performance of Williams is because of the increased prevalence and severity of the charcoal rot disease.

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The Hybrid Status of *Tridens oklahomensis* (Feath.) Feath.

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Abstract: *Tridens oklahomensis* (Poaceae) described earlier as the hybrid cross of *T. flavus* and *T. strictus* is expanding its range in Boone County, Missouri. Heretofore reported only from this county it was recently found in the southern part of the state. Possible explanations are presented for this widespread but disjunct occurrence. Field and laboratory studies are in progress to provide further documentation of hybrid origin, and to explain mechanisms for the possible formation of a new species.

Key Words: Hybrid, type specimen, pistillate parent, expanding hybrid populations, isolating mechanisms, disturbed habitats

Introduction

Tridens oklahomensis (Feath.) Feath. (Poaceae) was first described from eastern Oklahoma near Stillwater (Featherly 1938). Later it was also found in central Missouri (Kucera 1957). Kucera proposed that this taxon was the F₁ progeny of *T. flavus* (L.) Hitchc. and *T. strictus* (Nutt.) Nash. Subsequent studies of cytological and morphological characteristics of these grasses tended to support hybridization, with *T. strictus* probably the pistillate parent (Crooks and Kucera 1973). Type specimens from Oklahoma on deposit in the U.S. National Herbarium, and Missouri collections, were considered sterile. Mature florets showed no caryopses in material from either source. In addition, pollen viability of Missouri plants was less than 1%, as determined with aniline blue in lactophenol. A recent search for the hybrid at the type locality in Oklahoma was unsuccessful, the apparent cause being habitat disruption from agricultural development. Presently, Missouri represents the only known sites extant for this taxon.

Current Studies

In 1983, a single clump of *T. oklahomensis* was discovered along a roadside situation in southern Missouri (T26N, R7E, sect. 18, NE ¼, SW ¼, Route KK, Butler County). This new find raises the question regarding its origin in southern Missouri. Both parents are native and common to the region, but despite intensive search no hybrids were previously collected. Heretofore, we assumed the absence of hybrids in southern Missouri was attributed to critical differences in phenological development and probable lack of synchrony in flowering between parents. Conversely, the widespread and expanding evidence for hybridization at the more northerly locations in central Missouri is thought to be due to a breakdown in isolating mechanisms as adventive populations of *T.*

strictus invade disturbed habitats outside its native range, into naturally-occurring populations of *T. flavus*. The apparent chance occurrence of the hybrid at the southern locale, approximately 300 km from central Missouri populations, may be the result of seasonal departure from normal flowering patterns in either one or both parents. Vagaries of weather or roadside management such as spraying and mowing, or a combination of these factors, could be responsible for the phenological shift.

Additional work on *T. oklahomensis* in Missouri is currently in progress. Ecological studies and detailed mapping of the hybrid as it continues to multiply and expand concomitantly with the spread of *T. strictus* populations in central Missouri are important efforts in better understanding population relationships. Attempts to develop polyploidy and possible fertility with colchicine and the analysis of soluble proteins of the 3 grasses by electrophoretic methods are also underway to provide additional verification of hybrid origin. The spontaneous occurrence of *T. oklahomensis* in southern Missouri reiterates general questions concerning parentage of intermediate forms, and most importantly the mechanisms for their origin as pathways to new species.

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Additional Notes on Rare, Endangered and Unusual Missouri Fen Plants

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Abstract: Floristic data are presented for 13 rare, endangered or unusual vascular plant taxa located at 64 previously unreported fen stations in southeastern Missouri.

Key Words: Rare and endangered plants, fens, Missouri

Introduction

A recent natural area inventory (Orzell 1983a, 1983b) for fens (calcareous wet meadows) in Reynolds, Madison, Shannon and St. Francois counties of southeastern Missouri revealed numerous previously unknown stations for vascular plant taxa considered either rare or endangered in Missouri (Missouri Department of Conservation 1984). In early 1983 the inventory was expanded to include another 5 counties: Carter, Dent, Iron, Washington and Wayne. Partial inventories were also completed in Howell, Bollinger, Ste. Genevieve and Jefferson counties. This paper documents rare, endangered and unusual plant taxa encountered during these inventories. Many of the new stations also represent new county records.

Collection data, phenology and species associations are based upon field observations conducted at each rare plant station. Data recorded in parentheses after each taxa indicate the locality code, collection date, collector(s) name and collection number.

A station is defined as a specific locality which may consist of 1 or more populations. Voucher specimens are deposited at the Missouri Botanical Garden, in St. Louis, MO. Collection locations are county coded (SH = Shannon, STF = St. Francois, R = Reynolds, M = Madison, H = Howell, C = Carter, WH = Washington, W = Wayne, J = Jefferson, B = Bollinger) with numbers indicating a specific site. Specific locality data has been omitted from this paper, but has been forwarded to the Missouri Department of Conservation. Nomenclature follows Steyermark (1963).

Results

Aster puniceus L. var. *firmus* (Nees) T. & G. f. *lucidulus* (Gray) Fern, (Asteraceae), is abundant at a number of fens and increases upon cessation of light grazing pressure. Since numerous new stations were located, only 1 noteworthy collection is reported. A pink flower form, not encountered elsewhere in the study area, was collected from a calcareous seep fen (STF10, September 26, 1981, Orzell 477).

Calopogon tuberosus (L.) BSP., (Orchidaceae), is recorded from 9 Missouri counties (Summers 1981). A new station of nearly 100 flowering individuals was noted from a calcareous seep fen where the associates are *Rudbeckia fulgida* Ait., *Scirpus americanus* Pers., *Parnassia grandifolia* DC., *Satureja arkansana* (Nutt.) Briq., *Selaginella apoda* (L.) Fernald and *Liatris pycnostachya* Michx. (SH10C, June 18, 1982, Orzell 594).

Carex bromoides Schkuhr, (Cyperaceae), was first reported by Christ (1980) as a state record from Bollinger County. Two new stations were located, both in Wayne County. At W7F it is very abundant in deep shaded seep forest forming dense tussocks associated with *Corylus americana* Walt., *Osmunda regalis* L., *Athyrium filix-femina* (L.) Roth., *Carex crinita* Lam., *Impatiens capensis* Meerb., *Solidago patula* Muhl. and the moss *Climacium americanum* Brid. (June 18, 1983, Orzell 1016). At W7D it is occasional in seep forest with *Acer rubrum* L., *Fraxinus pennsylvanica* Marsh, *Alnus serrulata* (Ait.) Willd., *Carex lurida* Wahlenb., *Solidago patula*, *Scirpus polyphyllus* Vahl. and *Juncus effusus* L. (June 18, 1983, Orzell 1010). At the Bollinger County site (B1) *Carex bromoides* is rare along seep runs in rich mucky peat of a low wet cutover woods with *Carpinus caroliniana* Walt., *Ostrya virginiana* (Mill.) K. Koch, *Lindera benzoin* (L.) Blume, *Parthenocissus quinquefolia* (L.) Planch., *Rhus radicans* L., *Carex leptalea* Wahlenb., *Impatiens capensis*, *Solidago patula* and *Senecio aureus* L. (May 28, 1983, Orzell 923).

Carex stricta Lam. var. *strictior* (Dew.) Carey, (Cyperaceae), was located at 2 new stations in Dent County. At D15A associates are *Fuirena simplex* Vahl, *Rudbeckia fulgida* Ait., *Senecio aureus*, and *Parnassia grandifolia* DC. (June 9, 1983, Orzell 984). At D4B *Carex stricta* is locally abundant in areas of copious seepage in a sedge meadow-shrub fen (May 23, 1983, Orzell 914).

Chelone glabra L., (Scrophulariaceae), although not listed in Missouri as a plant of concern, is of unusual occurrence in study area fens. *Chelone glabra* has only been collected by the author from 5 fens, where it is locally frequent. Common associates include *Pedicularis lanceolata* Michx., *Solidago patula*, *Polygonum sagittatum* L., *Onoclea sensibilis* L., *Rudbeckia fulgida* and *Thelypteris palustris* Schott. Blooming extends from late August to late September (R37, September 11, 1981, Orzell 417; M6, August 17, 1982, Orzell 855; B1, September 25, 1981, Orzell 466; WH27, September 24, 1983, Orzell 1193; W9H, September 25, 1983, Orzell 1209).

Cirsium muticum Michx., (Asteraceae), was recorded from 9 counties by Steyermark (1963). The plant is believed to have been extirpated from St. Louis County and efforts to relocate the Washington, Howell, Bollinger and Ste. Genevieve stations have been unsuccessful. At present *C. muticum* is extant at 6 Missouri stations (SH14, M6, R61, C1, C3, SH26) with a seventh record reported from STF10 by Christ (1979). Typical associates of *C. muticum* in sedge meadow-shrub fens include, *Solidago patula*, *Pedicularis lanceolata*, *Aster puniceus*, *Scirpus atrovirens* Willd. and sometimes *Chelone glabra* or *Solidago riddellii* Frank. *Cirsium muticum* flowers primarily in late August and early September.

Filipendula rubra (Hill) Robins, (Rosaceae), has been located from 2 new stations (STF32B, H4) since the previous report in Orzell (1983c). Numerous plants were located in a calcareous seep fen (STF32B), a station which lies to the

east of the St. Francois State Park station located some years ago by the Webster Groves Nature Study Society (Orzell 1983c). Associates at STF32B include *Carex stipata* Muhl., *C. stricta*, *Aster novae-angliae* L., *Pycnanthemum virginianum* (L.) Durand & Jackson, *Rudbeckia fulgida*, *Salix caroliniana* Michx., *Oxypolis rigidior* (L.) C. & R. and *Glyceria striata* (Lam.) Hitchc. (July 31, 1983, Orzell 1068). A new station in Howell County (H4) was located in a prairie fen with *Andropogon gerardii* Vitman and *Pycnanthemum virginianum* (August 8, 1983, Orzell 1101).

Habenaria clavellata (Michx.) Spreng. [*Platanthera clavellata* (Michx.) Luer], (Orchidaceae), has been identified at 3 new Wayne County stations all from deeply shaded seep forests. *Habenaria clavellata* usually occurs on thick mossy hummocks of *Thuidium delicatulum* (Hedw.) B.S.G., *Climacium americanum* and *Sphagnum* sp. which form around the base of *Acer rubrum* or *Alnus serrulata* (W7F, no voucher; W7D, June 18, 1983, Orzell 1021; W9H, August 5, 1983, Orzell 1089, flowering specimen).

Liparis loeselii (L.) Richard, (Orchidaceae), was recently located from C12B, C12C, B1 and SH26, all representing previously unknown stations. At C12B *L. loeselii* is very rare, occurring in full sun of a calcareous seep fen above a spring branch with *Parnassia grandifolia*, *Oxypolis rigidior*, *Carex hystricina* Muhl. ex Willd., *Helenium autumnale* L., *Carex leptalea* and *Rudbeckia fulgida* (flowering on June 17, 1983, no voucher taken). *L. loeselii* is very rare at C12C in partial shade on quaking mucky peat with copious seepage in a calcareous seep fen, associated with *Impatiens capensis*, *Glyceria striata*, *Carex laevivaginata* (Kukenth) Mackenz., *C. lurida* and *Senecio aureus* (June 17, 1983, Orzell 994).

The new station in Bollinger County (B1) is from a sedge meadow-shrub fen. Associates include *Alnus serrulata*, *Salix sericea* Marsh., *Cornus obliqua* Raf., *Carex leptalea*, *Ludwigia alternifolia* L., *Carex lurida*, *Solidago patula*, *Solidago riddellii*, *Rudbeckia fulgida* and *Pycnanthemum virginianum* (May 28, 1983, Orzell 924 & Wilhelm).

At the new Shannon County (SH26) station *L. loeselii* occurs on the lower portion of a (hanging) calcareous seep fen. *Rudbeckia fulgida*, *Carex leptalea*, *Scirpus atrovirens* Willd., *Hydrangea arborescens* L., *Satureja arkansana*, *Cypripedium reginae* Walt. and *Eupatorium perfoliatum* L. are associates (no specimen taken, photographed on July 19, 1983).

Phlox maculata L. var. *pyramidalis* (Smith) Wherry., (Polemoniaceae), is presently known from 12 stations in Reynolds County, 1 station in Carter County, 1 station in Jefferson County and 1 new station in Washington County (WH27). Attempts to relocate the Dent, Iron and Ste. Genevieve County stations cited in Steyermark (1963) have been unsuccessful. At WH27 *Phlox maculata* occurs in a calcareous seep fen with *Salix nigra* Marsh., *Pycnanthemum tenuifolium* Schrad. and *Chelone glabra* (September 24, 1983, Orzell 1197).

Plantago cordata Lam., (Plantaginaceae), is under review for possible listing as either a federally threatened or endangered taxon (U.S. Fish and Wildlife Service 1983). Since Orzell's finding (1983c), new stations have been located from Dent (D15D) and Carter counties (C12B, C12D). At C12B it is known from partially shaded sections of a gravelly, clear, cold spring run in a sedge meadow-shrub fen with *Nasturtium officinale* R. Br., *Carex hystricina*, *C. interior* Bailey, *Cardamine bulbosa* (Schreb.) BSP, and *Senecio aureus* (June 17, 1983,

Orzell 995). The largest population noted during the inventory was along a remote high quality calcareous seep-fed stream in Carter County (C12) where thousands of robust plants of *P. cordata* occur in dense stands along and in the creekbed.

Scleria verticillata Muhl., (Cyperaceae), was collected from four new stations in St. Francois, Reynolds, Shannon and Washington counties. All collections were from marly (calcareous ooze) areas within fens. Associates frequently included *Satureja arkansana*, *Rhynchospora capillacea* Torr., *Rudbeckia fulgida*, *Parnassia grandifolia*, *Panicum flexile* (Gattinger) Scribn., *Lysimachia quadriflora* Sims and often *Fuirena simplex* (STF10, August 9, 1981, Orzell 367; R38, August 4, 1981, Orzell 835; SH10C, August 12, 1982, Orzell 846; WH27, September 24, 1983, Orzell 1199).

Solidago riddellii Frank, (Asteraceae), was only located at 7 stations (D15, D4E, M1E, R61, B1, WH27, J7A). Steyermark (1963) records *S. riddellii* as also occurring in Shannon, Phelps, Miller and Camden counties. Phelps and Miller counties need to be checked for extant populations. An extant population occurs in Camden County; however, the author was unsuccessful at locating any Shannon County populations. Typical associates are *Scirpus atrovirens*, *Rudbeckia fulgida*, *Lysimachia quadriflora*, *Cirsium muticum*, *Solidago patula* and *Pedicularis lanceolata*. Flowering occurs from late August to late September.

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Secondary Production in *Isonychia bicolor* (Ephemeroptera: Oligoneuriidae)

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Abstract: *Isonychia bicolor* (Walker) in southwestern Missouri is a bivoltine species with a short, rapidly developing summer generation of 3-4 months duration and a longer, more slowly developing winter generation of about 9 months duration. Growth is continuous during winter, and emergence is largely asynchronous during summer. Abundances ranged from 29.5 during May to 415.5 m⁻² during December and biomasses ranged from 57.7 mg during April to 405.3 mg dry wt m⁻² during August. Biomass averaged 220 mg for the summer generation and 150 mg for the winter generation. Cohort production was 1317 (\pm 275 95% confidence interval) mg dry wt m⁻² for summer and 981 (\pm 127) for winter. Annual production was 2298 (\pm 196) mg dry wt m⁻². Cohort turnover ratios were 6.0 during summer and 6.5 during winter, while annual turnover ratio was 12.0. Annual production estimated by summing values for each cohort did not differ significantly from that estimated by multiplying average annual cohort production by the number of generations per year.

Key Words: Mayfly, *Isonychia*, life history, secondary production, Ozark stream

Introduction

The mayfly inhabits riffles and other swiftly flowing waters over much of northeastern North America. Like other species of the genus, nymphs feed by sieving small organisms with numerous, long setae located on their forelegs (Coffman et al. 1971). Emergence appears to occur primarily during spring and fall, although it varies geographically (Leonard and Leonard 1962, Sweeney 1978), and the species is considered to be bivoltine (Sweeney 1978). Subimago body size and fecundity of winter generation animals are about twice those of summer generation animals (Sweeney 1978). Nymphal growth rates, net growth efficiencies and production:respiration ratios for females are about twice those for males (Sweeney 1978). Additionally, rates of development of both eggs and nymphs are accelerated by increasing magnitudes of diel temperature variation, with adult metamorphosis being more successful when daily maxima are >16 C (Sweeney 1978).

Sullivan (1981) studied *I. bicolor* in Finley Creek, Christian County, MO, from April 1979 until June 1980 to obtain comparative life history data from the western portion of the species' range. In general, his findings were consistent with the above and, like Sweeney (1978), he found that *I. bicolor* ingested primarily diatoms. Because there are no estimates of secondary production of insects or other zoobenthos from Ozark streams, we used the relatively complete series of abundance and size-frequency data from Sullivan (1981) to estimate secondary production.

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Study Area

Finley Creek, a tributary of the James River, has a drainage basin of about 650 km² and flows southwesterly through Webster, Christian and Stone counties. It is a perennial, fourth order stream throughout 75% of its 80 km length and has a moderate to low gradient, descending about 140 m. Discharge averages 20.5 m³ sec⁻¹, conductivity at 25 C averages 320 micromhos, pH averages 7.91, dissolved oxygen averages 9.4 ppm and water temperature averages 14.5 C (USGS 1970-1975). Its clear water, chert-gravel bottom and hard-water chemical characteristics are typical of Ozark streams.

Two riffles approximately 10 km upstream from Ozark, MO, were sampled during this study; one riffle was sampled qualitatively and the other quantitatively. Current velocities on the riffles ranged from 0.85 to 1.81 m sec⁻¹ with a maximum depth of about 0.5 m during periods of normal flow. Water temperatures during the study ranged from 4 to 25 C.

Materials and Methods

Subimagoes and winged imagoes were captured during daylight with an aerial net and during night with a fluorescent ultraviolet light trap. Nymphs were collected qualitatively using a handscreen with 1 mm² mesh size and quantitatively using a 30 cm² Surber stream sampler with a 1 mm² mesh size net. Qualitative samples were collected bi-weekly or monthly, while quantitative samples were collected monthly from September 1979 until February 1980, with a final sample being taken during May 1980. Size-frequency data from specimens collected quantitatively were supplemented with size-frequency data from specimens collected qualitatively. Numbers of samples used to estimate abundances are given in Table 1. All samples were preserved in 70% ethanol.

Head capsule widths of nymphs were measured (\pm 0.01 mm) with a dissecting microscope using a filar micrometer and grouped into 0.1 mm size intervals. Dry weights of a series of animals representing the size range were determined by drying freshly killed and measured specimens to a constant weight at 105 C and weighing them (\pm 0.01 mg) with a model 7500 Cahn Electrobalance. The head capsule width-dry weight relationship determined by regression analysis of log-transformed data was:

$$\text{Dry Wt}_{(\text{mg})} = 0.7879 \text{ Head Capsule Width}_{(\text{mm})}^{3.9148}$$

(N = 40, R² = 0.99)

Biomasses were calculated by multiplying the dry weight for each size class by the abundance of each size and summing the weights for each date.

Secondary production was estimated by the "size-frequency" or "Hynes method" (see Waters and Hokenstrom 1980) introduced by Hynes and Coleman (1968) and clarified by Hamilton (1969) using the computational procedures of Krueger and Martin (1980). As suggested by Benke (1984), negative estimates of production for the smaller size groups, which are likely due to non-linear developmental rates, were ignored in the estimates of production. Also, because the generations were of unequal length, production was computed separately for each generation and summed for an estimate of annual

production (Benke 1979). Menzie (1980) proposed an alternate method of estimating production; however, we felt we could separate cohorts and apply the calculations proposed by Krueger and Martin (1980) as accurately as we could estimate the production intervals for the 2 cohorts. The common estimate of variance for annual production was calculated by summing the sums of squares for each generation, dividing by their combined degrees of freedom and then multiplying by the square of the number of generations (Krueger and Martin 1980). Although Hynes' (1980) reservations about calculating confidence intervals for size frequency data are well founded and should be borne in mind, we feel that the procedure proposed by Krueger and Martin is nonetheless useful because it provides an explicit estimate of the sample error resulting from both estimates of abundance and size-frequency data in replicate samples.

Quantitative samples were not collected during March and May, but qualitative samples were. Abundance during March was estimated from interpolation of quantitative data collected during February and April, while abundance during May was estimated from interpolation of quantitative data collected during April and a final set of samples collected during June 1980. Numbers of individuals in each size category were determined by multiplying relative size-frequency data obtained from qualitative samples by the interpolated abundances.

Results

I. bicolor in southwestern Missouri displayed a bimodal pattern of seasonal abundance with a small peak during mid-summer and a larger peak during late fall (Fig. 1) with some lag in collection of large numbers of larvae due to the coarseness of the sampling net (e.g., see Suter and Bishop 1980). We believe this pattern was due to emergence and oviposition during spring and fall, respectively, and size-frequency data support this conclusion. However, aerial collections and occurrence of mature nymphs indicated that emergence occurred all summer long, although most commonly during spring and fall, leaving open the possibility of the occurrence of a single asynchronous generation *sensu* Landa (1968). Average seasonal abundances ranged from 29.5 to 415.5 m⁻², while maximum abundance in a single sample was about 767 m⁻². Head capsule widths of first instar nymphs reared from eggs averaged 0.14 mm and, assuming linear increase in size, suggests the first 3-4 instars were seriously undersampled.

Size-frequency data (Table 1) provided more detail and indicated that recruitment occurred prior to 6 July and again prior to 14 September. Presumably, individuals recruited before July develop rapidly into mature nymphs by the end of August, while individuals recruited at the end of summer develop into mature adults by the next spring. Head capsule widths of female imagoes ranged from 1.8 to 2.0 mm during fall and from 2.1 to 2.4 during spring.

Biomasses calculated from size-specific estimates of abundance (Table 1) were lowest during October (62.1 mg dry wt m⁻²) and highest during August (405.3 mg dry wt m⁻²).

Production for the summer generation was 1317 mg dry wt m⁻² per 3-4 months with a 95% confidence interval (CI) of ± 275 , while production for the winter generation was 981 mg dry wt m⁻² per 9 months with a 95% CI of ± 127 .

Table 1. Average numerical abundances m^{-2} and standard errors by head capsule width, and biomass (mg dry wt m^{-2}) by date, 1979-1980.

Head capsule width (mm)		3	6	20	14	27	14	4	20	20	20	2	11	11	9
		June (2)*	July (6)	July (5)	Aug (4)	Aug (7)	Sept (5)	Oct (6)	Nov (5)	Dec (5)	Jan (6)	Feb (8)	Mar (3)	Apr (5)	May (2)
0.15	\bar{X}	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.25	\bar{X}	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.35	\bar{X}	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	2.1	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0
0.45	\bar{X}	0.0	0.0	0.0	0.0	0.0	2.1	0.0	4.3	6.4	0.0	0.0	0.0	0.0	0.0
	SE	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.2	2.9	0.0	0.0	0.0	0.0	0.0
0.55	\bar{X}	0.0	0.0	6.8	5.4	0.0	4.3	5.7	28.0	45.2	12.5	1.3	0.0	0.0	0.0
	SE	0.0	0.0	1.9	2.7	0.0	1.2	0.9	3.3	9.9	1.8	0.5	0.0	0.0	0.0
0.65	\bar{X}	0.0	1.8	11.1	21.5	1.5	8.6	8.6	47.4	81.8	37.7	4.0	1.5	2.3	0.0
	SE	0.0	0.7	3.0	4.8	0.6	1.8	2.1	10.4	15.1	5.4	1.0	0.9	0.9	0.0
0.75	\bar{X}	0.0	0.1	17.3	21.5	0.0	6.4	10.6	66.7	73.2	41.3	20.2	2.4	2.1	0.5
	SE	0.0	0.0	5.4	2.0	0.0	1.9	2.0	12.3	12.7	3.8	3.3	0.8	1.0	0.3
0.85	\bar{X}	0.0	5.5	27.4	37.7	1.5	2.1	8.6	36.6	77.5	43.0	29.6	12.5	13.6	1.0
	SE	0.0	4.7	8.6	7.2	0.6	1.0	1.3	7.7	11.7	6.1	5.9	2.1	3.4	0.7
0.95	\bar{X}	0.6	2.1	30.3	32.3	4.8	8.6	1.4	30.1	51.7	52.0	41.7	21.8	4.7	1.2
	SE	0.4	0.7	9.1	4.4	1.7	2.8	0.5	6.0	7.0	8.2	5.1	0.5	1.9	0.5

1.05	\bar{X}	0.0	6.0	29.6	16.1	4.8	4.3	0.5	19.4	28.0	23.3	41.7	28.0	7.4	0.7
	SE	0.0	0.9	8.0	2.4	1.2	1.2	0.2	2.4	3.6	3.5	5.5	3.7	1.8	0.0
1.15	\bar{X}	0.6	2.8	19.5	29.6	5.0	6.4	0.2	6.4	30.1	28.7	26.9	25.7	1.9	2.6
	SE	0.4	0.8	6.5	8.2	1.2	1.2	0.0	1.9	4.9	5.4	4.1	4.9	0.9	0.4
1.25	\bar{X}	0.0	4.4	7.2	13.4	10.4	23.7	1.8	2.1	12.9	19.7	24.2	18.0	10.3	2.9
	SE	0.0	0.9	2.0	2.3	1.3	3.5	0.7	1.0	2.8	3.1	3.9	2.5	2.6	2.0
1.35	\bar{X}	1.9	6.3	5.4	32.3	7.3	12.9	0.1	0.0	4.3	7.2	9.4	15.4	3.7	4.0
	SE	1.4	1.4	1.9	6.2	1.4	3.5	0.0	0.0	1.2	1.5	1.3	2.0	1.0	0.5
1.45	\bar{X}	3.3	4.9	7.2	53.8	20.1	17.2	3.9	2.1	2.1	7.2	17.5	5.0	1.9	6.7
	SE	2.3	0.9	1.0	7.6	3.4	2.9	1.4	1.0	1.0	1.5	1.8	1.4	0.9	0.6
1.55	\bar{X}	8.0	6.7	7.9	0.0	15.0	15.1	7.7	0.0	0.0	1.8	1.3	4.1	0.1	4.7
	SE	2.0	1.3	2.8	0.0	3.9	4.5	1.8	0.0	0.0	0.7	0.5	0.6	0.0	1.2
1.65	\bar{X}	9.9	15.5	8.7	2.7	4.6	6.4	0.2	0.0	0.0	1.8	0.0	0.0	0.1	1.8
	SE	0.5	1.8	2.4	1.2	1.2	1.9	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.6
1.75	\bar{X}	11.9	2.1	3.6	0.0	0.2	2.1	0.1	0.0	0.0	0.0	0.0	1.5	0.2	2.8
	SE	0.8	0.7	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.9	0.1	0.6
1.85	\bar{X}	6.7	1.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	SE	2.9	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
1.95	\bar{X}	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
	SE	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Total average abundance		42.9	60.0	182.8	266.3	75.2	120.2	49.4	245.2	415.3	276.2	217.8	135.9	48.3	29.5
Biomass		250.1	200.8	260.1	405.3	213.8	275.3	61.9	99.4	210.0	227.2	255.8	200.7	57.5	99.6

*Number of samples in parentheses.

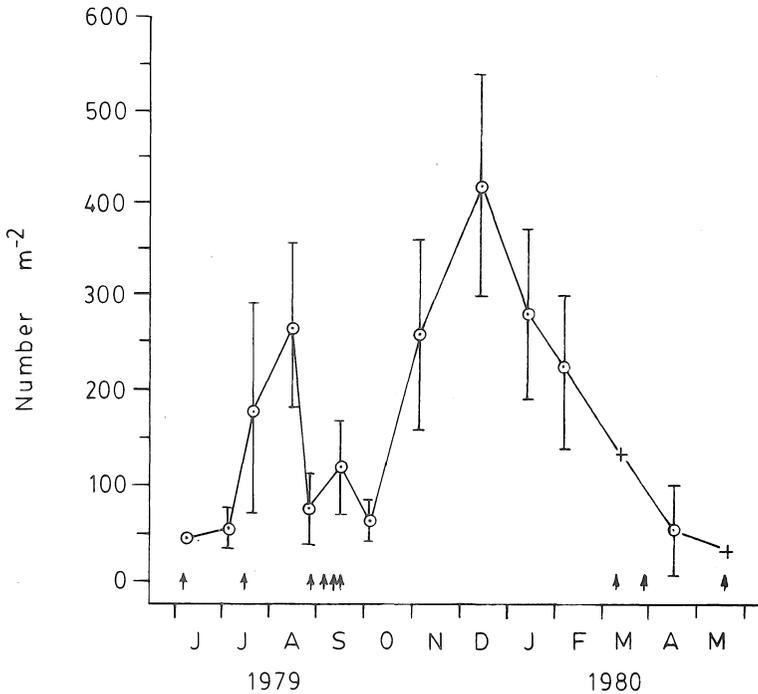


Fig. 1. Seasonal abundance (\pm standard error). Interpolated values are indicated by + and emergence is indicated by \uparrow .

Annual production for the 2 generations was 2298 mg dry wt m^{-2} with a 95% CI of 196. Annual production computed by multiplying the average annual rate by the number of generations (e.g., Hamilton 1969) would have been 2332 mg dry wt m^{-2} with a 95% confidence interval of \pm 239. Average summer biomass was 220 mg with a cohort turnover ratio of 6.0, while the average winter biomass was 150 mg with a cohort turnover ratio of 6.5. Average annual biomass was 192 mg, which, if divided into the estimate of annual production obtained by summing the estimates for summer and winter cohorts, would yield an annual turnover ratio of 12.0.

Discussion

Cohort turnover ratios for zoobenthos are on the order of 3.5 to 5, while annual turnover ratios are larger by a factor proportional to the number of generations (Waters 1977). The cohort turnover ratios for *I. bicolor* were slightly larger than the mode expected for zoobenthos in general, but are similar to those obtained for other Ephemeroptera.

Like Sweeney (1978), we observed a seasonal and sexual dimorphism in adult size, but we did not sex the nymphs. Therefore, we could not determine if

there was sexual dimorphism in production. In contrast to Sweeney, our data indicated that in southern Missouri *I. bicolor* continue to grow during winter.

Annual production estimated by summing the 2 separate generations (2.2 ± 0.28 g dry wt m^{-2}) did not differ significantly from the estimate obtained by multiplying the estimate of the average cohort by the number of generations (2.3 ± 0.24 g dry wt m^{-2}). However, because qualitative size-frequency data were adjusted with the same interpolated estimates of abundance for 3 samples during March and 2 samples during May, it is likely our estimates of variance for production were biased downward.

Our estimates of production and its variance were conservative because the Surber net was relatively coarse and would have undersampled the smallest nymphal stages. Based on estimates of fecundity for *I. bicolor* from White Clay Creek in Pennsylvania (Sweeney 1978) and abundances in Finley Creek just prior to peak periods of spring and fall emergence, production could be 50-75% greater. However, this would imply a turnover ratio of 15-17, which is relatively high.

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Ecological Observations of Eastern Spotted Skunks on the Ozark Plateau¹

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Abstract: Activity patterns, movements, habitat use and foods of eastern spotted skunks (*Spilogale putorius*) were studied with the aid of radio telemetry. Seven male skunks were captured and monitored for varying time periods; most data were from 4 individuals. Skunks were primarily nocturnal. They were active more often and for longer periods during spring and summer than during fall and winter. Home range size was correlated with the number of radio locations. One skunk ranged over a 4359-ha area during a 13-month period. Skunks used oak-hickory forests more than other habitats, especially areas with moderate to high amounts of ground litter. Bottomland areas were seldom used. Dens were found in hollow logs, standing hollow trees, rocky outcroppings and burrows. Orthoptera, Coleoptera and Hymenoptera comprised the principal foods during summer and fall; small mammals were also important during fall months.

Key Words: spotted skunk, *Spilogale putorius*, habitat, activity, foods, dens, movements

Introduction

Activity, movement and habitat use patterns (Crabb 1948), foods (Selko 1937, Crabb 1941) and dens (Crabb 1948) of spotted skunks have been examined in agricultural areas, but spotted skunks are found more commonly in woodland habitats in Missouri and elsewhere (Sampson 1980). Because little is known of spotted skunk habits in general, and the landscape of the Ozark Plateau differs from that commonly described as spotted skunk habitat, the objectives of this study were to describe activity, movement and habitat use patterns, foods and dens of spotted skunks on the Ozark Plateau.

Study Area and Methods

This investigation was conducted from January 1981 through April 1982, and was concentrated on an 80 km² study area located 20 km NE of Eminence in Shannon County, MO (37°15'N, 91°15'W), within the Salem Plateau physiographic region (Bretz 1965). A habitat map was developed from aerial photographs and verified from transects placed systematically on the study area.

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those of all skunks monitored. No winter activity was recorded during the 4 nights 1 skunk was monitored, but it used at least 5 different dens in 2 months, so some winter activity occurred.

Spotted skunks on the Shannon County area occupied home ranges ranging in size from 55 to 4359 ha during intervals of 3 weeks to 13 months (Table 1).

Table 1. Minimum-area home ranges (ha) for radio-tagged spotted skunks in Shannon County, MO, by season during 1981 and 1982. Numbers of radio-locations used to calculate home ranges are presented in parentheses.

Animal no.	1981			1982		Composite
	Spring	Summer	Fall	Winter	Spring	
M083				40(15)	0(4) ^a	244(19)
M123			55(40)			55(40)
M680	2654(150)	193(114)	104(44)	5(24)	2907(47)	4359(379)
M842	1027(28)					1027(28)

^aAll 4 locations were made during 1 night that the animal was sedentary.

Although home range size was correlated directly with the number of radio-locations ($r = 0.96$), skunks had the largest home range during spring.

Spring movement rates of 1 skunk (423 m/hour) were significantly different than its summer rates (252 m/hour, $t = 0.08$, $P < 0.05$). Mean nightly movement, including intervals when the skunk was sedentary, was greater in spring (2807 m) than in summer (1622 m, $t = 1.85$, $P < 0.01$) or fall (1038 m, $t = 2.64$, $P < 0.05$). Mean nightly movements during summer were not significantly different than those during fall ($t = 1.13$, $P > 0.2$).

Large home-range sizes and extensive movements during spring possibly were related to breeding activity (Mead 1968), or were an indication that populations were at low densities. Home ranges of males in spring in Missouri were more than twice as large as those estimated for males in Iowa by mark-recapture (Crabb 1948). However, populations as reflected in recorded fur harvests are presently much lower on the Ozark Plateau than in Iowa during the mid-1940's (Sampson 1980, R. Andrews, pers. comm.).

Winter inactivity possibly was affected by carnivoran lethargy (Aleksiuk and Stewart 1977). This phenomenon was reported for spotted skunks (Crabb 1948) and striped skunks (*Mephitis mephitis*) (Verts 1967, Sunquist 1974); however, there are insufficient data to support or refute its occurrence in Missouri.

Habitat Use

Oak-hickory forest comprised 92% of the Shannon County area, and 86% of all radio locations were in that habitat type (Table 2). Within the oak-hickory type sites with moderate or high levels of ground litter or slash appeared to be used more than sites with a clean forest floor. Skunks were located most often in

Table 2. Percent seasonal use and habitat availability expressed as a percent of composite home range, for individual spotted skunks in Shannon County, MO. Percent seasonal use in bold print indicates a significant difference ($P < 0.05$) from availability tested by use of chi-square. Numbers in parentheses indicate number of radio-locations.

Habitat type	Spring				Summer		Fall				Winter					
	M842/1981		M680/1981		M680/1982		M680/1981		M123/1981		M680/1981		M083/1982		M680/1982	
	(21)		(114)		(32)		(80)		(15)		(17)		(10)		(8)	
	Use Avail		Use Avail		Use Avail		Use Avail		Use Avail		Use Avail		Use Avail		Use Avail	
Oak-hickory forest	100	99.7	91.2	91.5	96.9	91.5	76.3	91.5	100	100	70.6	91.5	100	100	0	91.5
Old field	0	0	4.4	4.3	0	4.3	2.5	4.3	0	0	11.8	4.3	0	0	0	4.3
Riparian edge	0	0	3.5	3.5	0	3.5	0	3.5	0	0	0	3.5	0	0	0	3.5
Glade	0	0.3	0.9	0.7	3.1	0.7	21.2	0.7	0	0	17.6	0.7	0	0	100	0.7

upland wooded sites. No inactive skunks were located in bottomland sites, comprised of riparian edge and old field. These areas were used irregularly as travel lanes from 1 forested ridge to another, but on no more than 2 consecutive radio-locations of active skunks. Glades accounted for less than 1% of all available habitat, and were seldom used during spring when movements were extensive. However, glades were the second most used component during summer activity, and accounted for 69% of 1 skunk's inactive radio-locations during fall and winter.

Den sites were examined 59 times; 17 during spring, 12 during summer, 20 during fall and 10 during winter. Twenty hollow logs, with an average diameter of 35.6 ± 10.2 cm, were used 23 times as dens. Skunks were located 10 times in 7 standing hollow trees with an average diameter at breast height of 26.3 ± 8.7 cm. Entrances were 1-7 m above ground. Two burrows were used 3 times and 12 sites in rocky outcroppings were used 23 times. Rocky outcroppings ranged in size from approximately 1 by 2 m to large outcroppings which stretched across hillsides. Eighty-one percent of all dens were located in oak-hickory forest. Nineteen percent were associated with glades; no dens were found in bottomland habitats.

Spotted skunks appeared to select den sites for their thermal suitability. All but 1 spring den were situated above ground. During summer underground dens were used 67% of the time, and 58% of summer dens faced in a northerly direction. As temperatures dropped during fall, underground dens were still used most often but 80% faced in a southerly direction. All winter dens faced in a southerly direction.

Food Habits

Forty-one droppings were collected: 6 during summer, and 35 during fall (Table 3). Principal summer foods were small, well dispersed and numerous. Orthoptera, Coleoptera and Hymenoptera occurred in all droppings and contributed 67% of the aggregate volume. All insects comprised 74% of the aggregate volume, while 3% was attributed to mammals. Principal fall food items were typically less numerous in the environment but were more concentrated sources of energy. Insects occurred in all droppings and comprised 53% of the aggregate volume, but insects found in concentrations—such as coleopteran larvae, vespidae wasp nests and scarab beetle colonies (Borror and White 1970)—contributed 70% of the insect volume. Percent volume attributed to mammals rose to 34%. Small rodents were the most commonly identified mammals, and *Peromyscus* spp. was identified in 4% of droppings collected in fall.

Discussion

We readily acknowledge that the information presented here is limited by small samples and that the telemetry data are restricted to males. Therefore, caution must be used in interpretation of our results. Yet because the only ecological studies of *Spilogale* were conducted over 35 years ago when skunk populations were much higher and where the environment was vastly different, we believe our data significantly further the knowledge of this species.

Differences in activity and movement patterns of spotted skunks during

Table 3. Food items identified in droppings collected during summer and fall 1981 in Shannon County, MO. The number of droppings are presented in parentheses.

Food item	Summer (6)		Fall (35)	
	% occur	% vol	% occur	% vol
Mammal	66.7	3.2	65.7	33.6
Bird	83.3	0.3	14.3	2.2
Insect	100.0	74.2	100.0	52.5
Coleoptera	100.0	16.9	91.4	25.5
Adult	100.0	15.6	74.3	13.0
Larvae	83.3	1.3	62.9	12.5
Hymenoptera	100.0	13.6	62.9	13.0
Orthoptera	100.0	36.1	74.3	12.3
Hemiptera (pentatomid)	100.0	7.6	77.1	1.4
Diptera (pupa)			2.9	tr
Unknown insect			2.9	0.2
Arachnid	66.7	3.2	14.3	0.2
Diplopod	16.7	0.3	2.9	0.3
Chilopod			2.9	tr
Plant	66.7	2.2	54.3	3.0
Debris		15.8		8.4

summer and fall possibly were related to a change in foraging patterns. Summer activity and movement patterns are consistent with the use of small, well-dispersed yet abundant foods such as insects. Fall activity and movement patterns are consistent with the use of more concentrated, less abundant foods such as small mammals and insect larvae.

Insufficient data were gathered to make definitive conclusions concerning spotted skunk behavior and habitat requirements. However, they appear well-adapted to the Ozark Plateau. Spotted skunks used the most common habitat type (oak-hickory forest) most often. Use of particular stands was apparently influenced by the amount of ground cover. Ground cover, in the form of rocky outcroppings, fallen logs or brush piles, provided habitat for common food items (insects and small mammals) as well as potential dens for spotted skunks.

In contrast, investigations in agricultural regions showed that spotted skunks relied heavily on human activities for survival. In Iowa, 87% of all dens were related to agricultural activity (Crabb 1948). Crippled waterfowl and stored grain and associated pests were major fall and winter foods (Selko 1937, Crabb 1941). Thus, it appears that high spotted skunk populations in agricultural regions in the mid-20th century were maintained, in part, by habitats associated with small farms.

Spotted skunk populations on the Ozark Plateau probably have remained relatively stable over the past 30 years (Sampson 1980). This region is

predominantly forested and agriculture is a minor land use. Although populations are undoubtedly low and well-dispersed, the extensively forested Ozarks appear to provide an acceptable environment for the species.

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Breeding Range and Population Status of the Greater Prairie Chicken in Missouri¹

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Abstract: Approximately 460,000 ha in 30 counties were surveyed during the spring of 1983 and 1984 for active leks of greater prairie chickens (*Tympanuchus cupido*). A total of 338 leks were located in 21 counties. The breeding range is estimated to comprise 187,000 ha, a 72% decline from the range in 1940. The spring breeding population is estimated at 5,500-6,500 birds. Loss of native prairie to agriculture is primarily responsible for the decline.

Key Words: Missouri, greater prairie chicken, breeding range, population status, prairie

Introduction

Prairie chickens once occurred throughout most of northern and western Missouri (Bennitt and Nagel 1937). Extent of the original range is unknown, but estimates exceeding 7.3 million ha have been proposed (Bennitt 1939, Bennitt and Nagel 1937). Presettlement prairie is estimated to have once covered nearly 4.8 million ha in Missouri (Schroeder 1981) and this figure may better reflect the extent of the original range.

By the early 1940's, the range of the prairie chicken in Missouri (Fig. 1) had declined to approximately 650,000 ha, an 86% loss of the original range based on presettlement prairie (Schwartz 1945). By 1979, less than 250,000 ha of occupied range was believed to remain, a mere 5% of the presettlement prairie (Christisen 1979, Christisen and Krohn 1980). The cause for this decline has been linked directly to the conversion of native prairie to cropland and cool season grass monocultures (Christisen and Krohn 1980).

This most recent estimate of prairie chicken range in Missouri (Christisen 1979) was based largely on the loss of almost all historical range north of the Missouri River. The historical range south of the Missouri River was presumed virtually intact in 1979. Although field reports during the years since 1979 generally supported this conclusion (Christisen, unpubl. data), an intensive survey was warranted because nearly 40 years had passed since Schwartz's (1945) statewide survey. The objectives of this survey were to determine the current breeding range and population status of the greater prairie chicken in Missouri.

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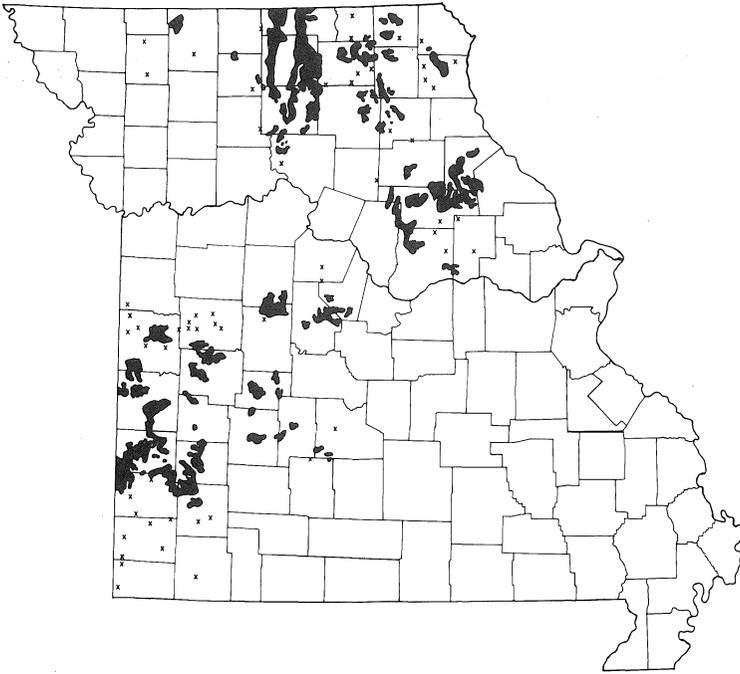


Fig. 1. The 1940 range of the greater prairie chicken in Missouri.

x: confirmed sighting

Study Area and Methods

In fall 1982, a questionnaire was sent to Conservation Agents and Biologists of the Missouri Department of Conservation in 66 counties from which little information had been received on population trends since Schwartz's 1945 survey. The results of the questionnaire indicated populations of prairie chickens likely remained in at least 30 counties (Table 1). Maps for the range survey were prepared for the 30 counties, based on historical range (Schwartz 1945) and questionnaire survey results. The survey was limited to the historical range and recent reports to ensure completion of the survey in 2 breeding seasons.

Surveyors were asked to record the location of active leks and categorize lek size, if possible. Six size classes (I = 1-10, II = 11-20, III = 21-30, IV = 31-40, V = 41-50, VI = 51-60) were used to record relative lek size, based on the number of males in attendance. Field work was conducted during March and April 1983 and 1984 on mornings without rain and with wind speed less than 20 miles per hour. Using existing roads, surveyors attempted to census 10 miles of route each morning, stopping for 3 minutes at 0.5-mile intervals to listen for vocalizations by displaying males. Under ideal conditions, vocalizations can be heard 1-2 miles away. Surveyors planned each morning's work based on the

Table 1. Number of spring leks, breeding range and estimated population size in Missouri counties 1983-1984. Counties selected for survey were based on results of Agent/Biologist questionnaire.

County	No. leks	Percent Class I	Breeding range (ha)			Estimated spring population size
			1940 (Schwartz 1945)	1983	Percent change	
North Missouri:						
Audrain	23	78	55,328	15,507	- 72	300
Monroe	6	100	7,691	4,066	- 47	55
Ralls	3	100	19,740	1,707	- 91	27
Callaway	2	100	12,297	1,606	- 87	18
Randolph	—	—	—	—	—	—
South Missouri:						
Barton	64	70	50,524	32,906	- 35	1,163
Dade	53	72	19,951	24,874	+ 25	863
St. Clair	28	54	20,987	13,732	- 35	636
Pettis	30	67	10,364	16,064	+ 55 ^b	454
Benton	16	63	11,400	8,032	- 29	309
Morgan	19	79	18,655	10,105	- 46	282
Lawrence	15	53	6,996	7,773	+ 11	336
Vernon	19	89	27,465	11,919	- 57	209
Jasper	11	73	10,623	7,255	- 32	173
Henry	13	85	4,923	6,478	+ 32 ^b	173
Cooper	8	63	—	5,441	— ^a	118
Moniteau	8	88	7,255	4,405	- 39	91
Bates	5	100	21,764	4,146	- 81	64
Cedar	5	100	4,146	3,368	- 19	46
Newton	4	100	4,405	2,332	- 47	36
Hickory	3	100	9,328	2,332	- 75	27
Johnson	3	100	—	2,591	— ^a	27
Polk	—	—	7,773	—	—	—
Greene	—	—	1,036	—	—	—
Cass	—	—	1,814	—	—	—
McDonald	—	—	1,296	—	—	—
Barry	—	—	518	—	—	—
Dallas	—	—	3,368	—	—	—
Webster	—	—	518	—	—	—
Laclede	—	—	2,850	—	—	—

^aNo data available for comparison.

^bIncrease due in part to documentation of additional range by Christisen following Schwartz's survey.

assumption that an area 1 mile either side of the census route was effectively censused. Censusing began ½ hour before sunrise and continued for up to 2 hours after sunrise. Upon completion of a route each morning, surveyors retraced the route to pinpoint the location of leks heard, but not visually located.

In the event a lek could not be located, the legal description to the nearest quarter-section was deemed sufficient. Leks heard, but not visually located were placed in size Class I and were included in the estimate of population size.

The locations of all leks were plotted on county highway maps. Breeding range was defined as a 1-mile radius around each active lek, because hens characteristically nest within 1 mile of the lek on which they mate (Hamerstrom and Hamerstrom 1973, Robel et al. 1970). The scattered segments of the breeding range were depicted as the outer boundary of 1-mile radius circles (with an active lek at the center) overlapping or touching. The resulting segments were measured to determine size of the breeding range and lek density.

Minimum spring population densities were projected from categorical lek size data. For each of the 6 size classes, the mid-range value was used to determine the potential number of males in the spring breeding population. A sex ratio of 1.2 males/female (55/45%) was used to project the total spring population size (Baker 1953, Johnsgard 1973).

Results

Nearly 460,000 ha were censused for active leks in 26 of the 30 counties in March-April 1983. An additional 79,000 ha in the remaining counties were censused in April 1984. Active leks were located in 21 counties (Table 1). A total

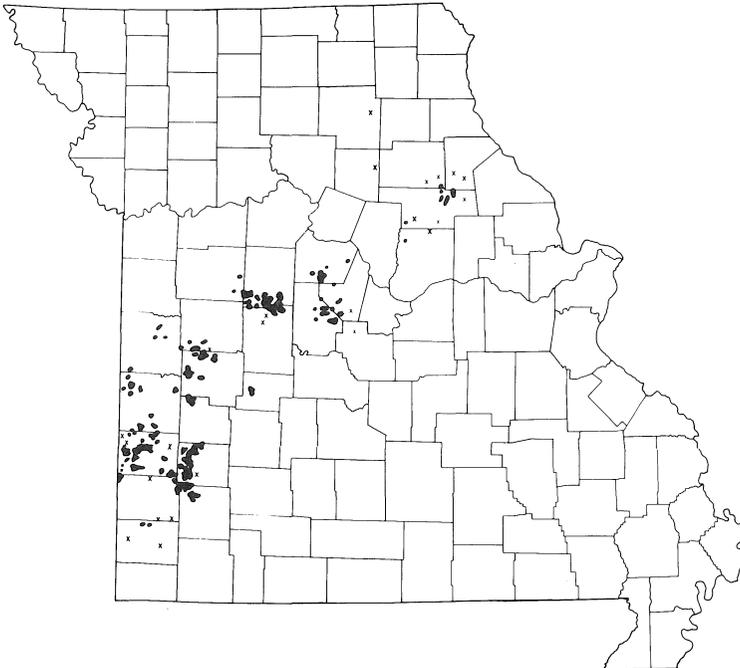


Fig. 2. The 1983 breeding range of the greater prairie chicken in Missouri.

x: confirmed sighting

of 338 leks were located, 73% of which were assigned to class size I. Breeding range in the 21 counties comprised nearly 187,000 ha (Table 1). The breeding range was divided into 70 distinct segments (Fig. 2), varying approximately 800-20,000 ha in size. Lek densities ranged from 1 lek/864 ha to 1 lek/370 ha (0.3-0.7 leks/mi²). Statewide, 72% of the 1940 range has been lost, at least as breeding range, as evidenced by the absence of active leks. Since 1940, the range declined 34% in south Missouri compared to a 94% decline in north Missouri. On the basis of presettlement prairie, less than 4% (187,000 ha) of Missouri's prairie chicken range remains. The spring 1983 population in south Missouri was projected as 5,000-6,000 birds. The spring 1984 population in north Missouri was projected as 400-500 birds.

Discussion

Tallgrass prairie originally covered almost 30% of western and northern Missouri (Schroeder 1981). Today, less than 1% of Missouri's native prairie remains (Reese 1984, Schroeder 1981). Almost 80% of the remaining populations of prairie chickens in Missouri are closely associated with the remaining tracts of native prairie in Missouri. Unfortunately, there is no evidence to suggest that loss of native prairie in Missouri has abated. The few populations of prairie chickens in Missouri that presently survive in non-prairie habitats (e.g., cool season grass pasture, wheat, row crops) are low density, small and isolated.

Lack of permanent grass suitable for nesting and brood rearing is believed the primary factor limiting prairie chicken populations in Missouri and neighboring states (Arthaud 1970, Christisen 1969, Hamerstrom and Hamerstrom 1973, Kirsch 1974, Sanderson et al. 1973, Yeatter 1943). Native grasses have proven superior to introduced cool season grasses for all activities of prairie chickens, because management of native grasses is more compatible with prairie chicken biology than management of cool season grasses (Gates 1982, Kirsch 1974). Although prairie chickens can survive in cool season grass pastures (e.g., fescue *Festuca elatior*, timothy *Phleum pratense*, smooth brome *Bromus inermis*) that are lightly grazed, the ability of cool season grasses to withstand heavy grazing pressure leaves most pastures in Missouri with inadequate cover for nesting and over-winter survival. June haying of cool season grasses is incompatible with prairie chickens because most nests hatch during early and mid-June. Conversely, properly managed warm season native grasses are never grazed below a 6-8 inch stubble height, and are hayed in mid-July, well after the June hatching peak (Gates 1982, Missouri Conservation Commission 1980).

The pattern of increased fragmentation of breeding range as a result of habitat loss has occurred in several other states, as well as in Missouri (Hamerstrom et al. 1957, Westemeier 1980, Yeatter 1943). Range fragmentation is typically followed by extirpation of the smallest populations of prairie chickens. Almost all small, isolated range segments reported by Schwartz (1945) have been lost in Missouri. As breeding range continues to fragment in Missouri, local prairie chicken populations will continue to become increasingly isolated and will ultimately disappear due to loss of nesting cover. Isolated populations in marginal habitat typically persist for many years, gradually declining in numbers until such time when cover becomes so marginal that severe weather conditions and/or predation can cause the extirpation of these local populations.

Table 2. Spring lek counts (1962-1983) on 1,545 leks in Missouri (Christisen 1985).

Size class	Size range	No. leks	Average lek size	%
I	1-10	803	4.3 ^a	52.0
II	11-20	424	15.1	27.4
III	21-30	202	24.7	13.1
IV	31-40	82	34.5	5.3
V	41-50	24	45.1	1.5
VI	51-60	7	53.6	0.5
VII	61-70	3	63.3	0.2

^aIncludes single males. Average lek size without single males was 4.6. Single male leks comprised 11.0% of all leks and 21.2% of Class I leks.

Small leks (Class I) have typically comprised approximately 1/2 of all leks censused in Missouri each spring (Table 2). Implications of the substantially higher percentage (72%) of Class I leks found in this survey are not yet fully understood. However, the higher values (Table 1) are clearly associated with the smaller, more fragmented range segments, and therefore may imply population instability. This conclusion is partially substantiated by the fact that greatest mating success and visitation by hens occurs on Class II leks (Hamerstrom and Hamerstrom 1955).

Because prairie chickens have yet to be successfully reintroduced into restored habitat, preservation of the remaining populations in Missouri must begin in the very near future if extirpation of the species is to be prevented. Preservation and proper management of key tracts of native prairie by landowners, private groups and public agencies will ensure the survival of local flocks by insulating them from major changes in agricultural practices. The planting and subsequent proper management of warm-season grasses (Gates 1982) by landowners in areas with remnant flocks of prairie chickens will significantly increase the amount of adequate habitat for both nesting and winter survival.

Acknowledgments

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Histologic Cycle of the Mourning Dove Crop

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Abstract: Histologic changes in the crop mucosa of mourning doves (*Zenaida macroura*) during a breeding cycle are described, and key stages are illustrated by photomicrographs. By Day 7 (incubation) the crop epithelium was thickening and primary folds appeared. By Days 10-11 (incubation) some sloughing of the surface epithelial cells into the crop lumen was evident, presaging "crop milk" formation. By Day 14 (hatch) the epithelial thickness was markedly lower; however, the sloughing rate was maximal. At about Day 31, 5 days after the young fledged, crops of females regained their pre-incubation appearance; in male parents, this condition occurred about 2 days later. Crop gland activity in the mourning dove began by about 7 days incubation, similar to other well-studied columbids. Duration and time of termination of crop-gland activity differ in these species, as expected, according to lengths of their breeding cycles.

Key words: mourning dove, *Zenaida macroura*, crop-gland histology

Introduction

Mourning doves, like other members of the family Columbidae (order Columbiformes), feed their young a substance termed "crop milk." The entire crop mucosa is involved in "milk" production except for the strip along the median line (Taylor 1941). It is stimulated by prolactin as first described by Riddle et al. (1932). Functions and controls of crop glands in columbids of both sexes have since been studied extensively (Lehrman 1955, Chadwick 1983). "Crop milk" consists of nutrient-rich epithelial cells sloughed from the crop mucosa (Levi 1977); immediately after hatching, squabs are fed almost entirely on this substance by both parents. Mourning doves are multi-brooded; the crop mucosa undergoes cyclic changes at each nesting during the breeding season, and is quiescent at some point before each new brood hatches.

Since the crop is a diverticulum of the lower esophagus, it has essentially the same microscopic anatomy (Hodges 1974). The innermost layer is the tunica

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mucosa consisting of a thin, rather incomplete smooth muscle layer, the lamina muscularis mucosae; the lamina propria, composed of connective tissue with many blood and lymph vessels and nerves; and a stratified squamous epithelial lining. The basal layer of the epithelium has been variously termed the stratum germinativum (Patel 1936), the stratum basale (Dumont 1965) or the proliferating layer (Litwer 1926). For columbids, the multicellular layer above the stratum basale is referred to as the nutritive epithelium (Beams and Meyer 1931). Dumont (1965) subdivided this layer into the stratum spinosum consisting of polyhedral cells resembling spinous cells described in mammalian stratified squamous epithelium and the stratum disjunctum, which is the surface layer of desquamating epithelial cells.

In columbids, an increase in vascularity of the lamina propria during incubation is physiologically important, providing nutrients and synthetic products to the overlying squamous epithelium. There is some continual epithelial desquamation in the crops of columbids, but the amount and rate of this exfoliation increase substantially when "crop milk" is formed (Beams and Meyer 1931). Desquamated cells contain synthesized lipid and protein; the lipid content is quite high, an important energy source for the squab when it hatches (Chadwick 1983).

Detailed descriptions of histologic changes in the crop mucosa of columbids are available principally for the rock dove or domestic pigeon (*Columba livia*; e.g., Patel 1936) and the band-tailed pigeon (*Columba fasciata*; March and Sadleir 1970). Gross changes in the crop according to position in the nesting cycle were described for the band-tailed pigeon by Zeigler (1971), the ringed turtle-dove (*Streptopelia risoria*) by Lehrman (1964) and for the mourning dove by Mirarchi and Scanlon (1980, 1982).

In this paper we describe histologic changes in the crop mucosa of mourning doves of both sexes according to position in the nesting cycle. This information provides a background for comparing duration of the crop gland in early vs. late season nestings and for assessments of the significance of active crop glands in doves shot by hunters (Books-Blenden et al. 1984).

Methods

Breeding pairs of captive and wild mourning doves were sacrificed at strategically chosen intervals (Table 1). The captive doves were sacrificed in morning hours to minimize variability of results related to diurnal crop-gland changes (Zeigler 1971). Wild doves with known nesting history were collected in morning hours when possible. Crops were removed and fixed in 10% formalin, infiltrated with Paraplast under vacuum and embedded. Sagittal sections 6 μm thick were prepared and stained with hematoxylin and eosin. The total width of the crop wall and the height of the largest fold in each section were measured with a calibrated ocular reticle. Although the entire crop wall was measured, any change in total thickness was due to epithelial growth.

Results and Discussion

The crop wall of non-breeding mourning doves was similar to that of other columbids, as described earlier (Fig. 1). The entire crop wall was thin, with little

Table 1. Numbers of mourning dove crops examined, listed according to source, sex of bird, and position in the nesting cycle.

Days after second egg laid	Wild doves		Days after second egg laid	Captive doves	
	Male	Female		Male	Female
1	1	1	26 (fledge)	1	1
2		1	29		1
3	2	1	30	1	
7	1	2	31	2	1
8	2	1	33	2	2
9	1		35	3	3
10	2	1		9	8
11	1	1			
13		2			
14 (hatch)	2				
15	1	1			
16	1	1			
17	1	2			
18		1			
19	1	2			
21	4				
22	1				
24	<u>1</u>	<u>—</u>			
	22	17			

evidence of vascularity. The distinct stratum basale stained dark and little epithelial folding was evident.

Events in Crop-Gland Development and Regression

Histologic changes that occurred during the crop-gland cycle are presented below. They involved the tunica mucosa: growth in epithelial thickness, folding of the epithelium, sloughing of surface cells and increase in the number of capillaries in the propria. The time frame provided is days after laying of the second egg, as incubation begins immediately afterwards.

Day 7 (incubation). In both male and female, the thickness of the epithelium increased noticeably, and the first primary folds appeared.

Days 8-9 (incubation). Epithelial folding was extensive, secondary folding was evident and vascularity of the propria increased considerably. The foamy appearance of the nutritive epithelium may indicate many foci of lipid accumulation. The stratum basale was thick and well defined (Fig. 2).

Days 10-11 (incubation). Fusion of the folds was nearly complete (Fig. 3). The epithelium attained its maximal width and began to decrease (Fig. 4). The stratum basale was no longer sharply defined. Many epithelial cells had large

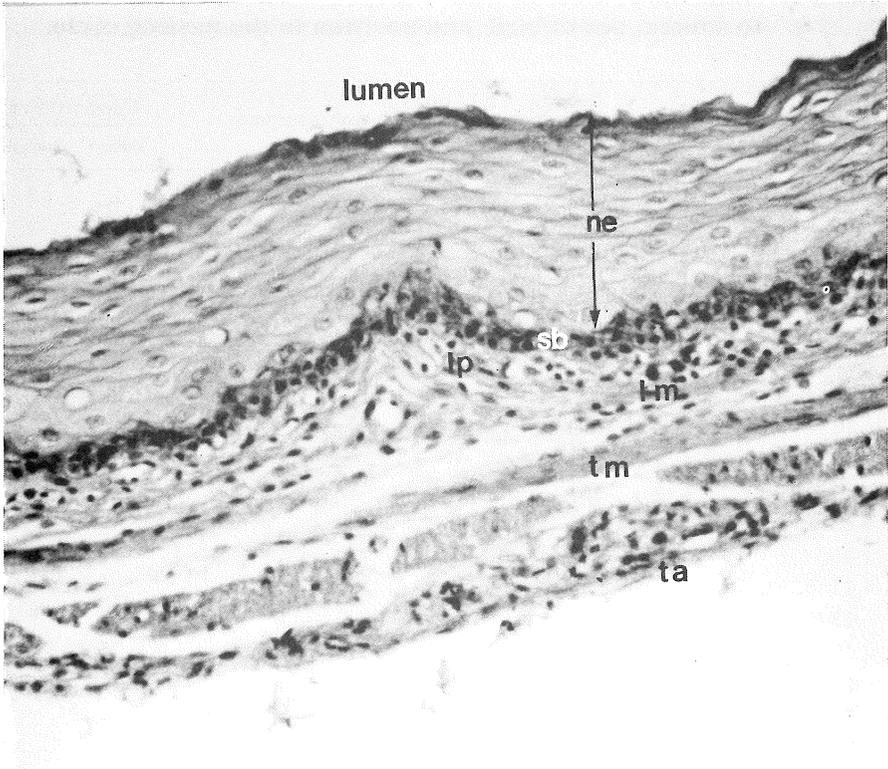


Fig. 1. Cross-section of wall of quiescent crop of immature mourning dove, showing layers (380x); ne = nutritive epithelium, sb = stratum basale, lp = lamina propria, lm = lamina muscularis, tm = tunica muscularis, ta = tunica adventitia.

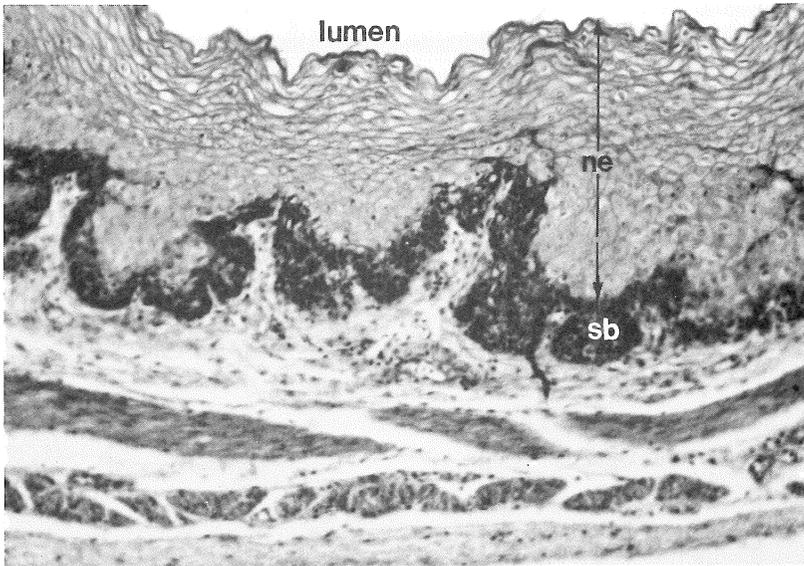


Fig. 2. Cross-section of crop wall of adult male mourning dove at Day 8 (incubation) (145x). Note foamy appearance of nutritive epithelium; ne = nutritive epithelium, sb = stratum basale.

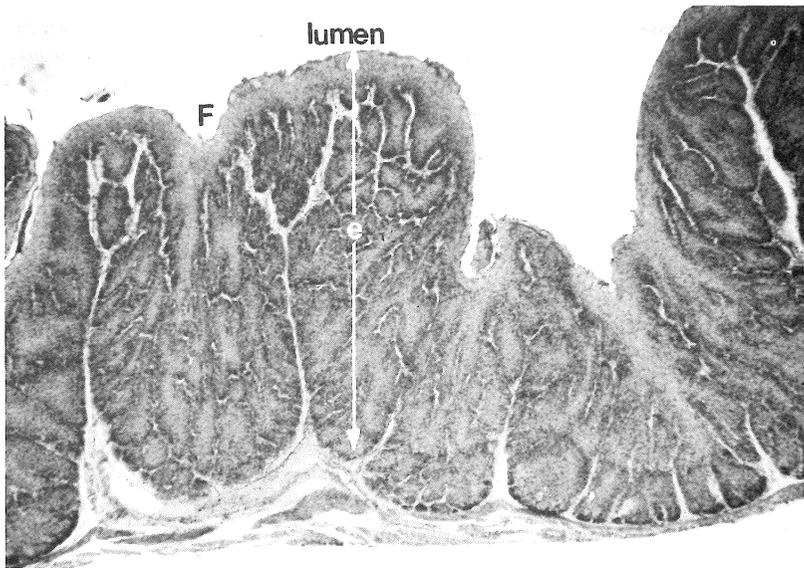


Fig. 3. Cross-section of crop wall of adult male mourning dove at Day 10 (incubation) (48x); F = area of fusion of folds, e = epithelium.

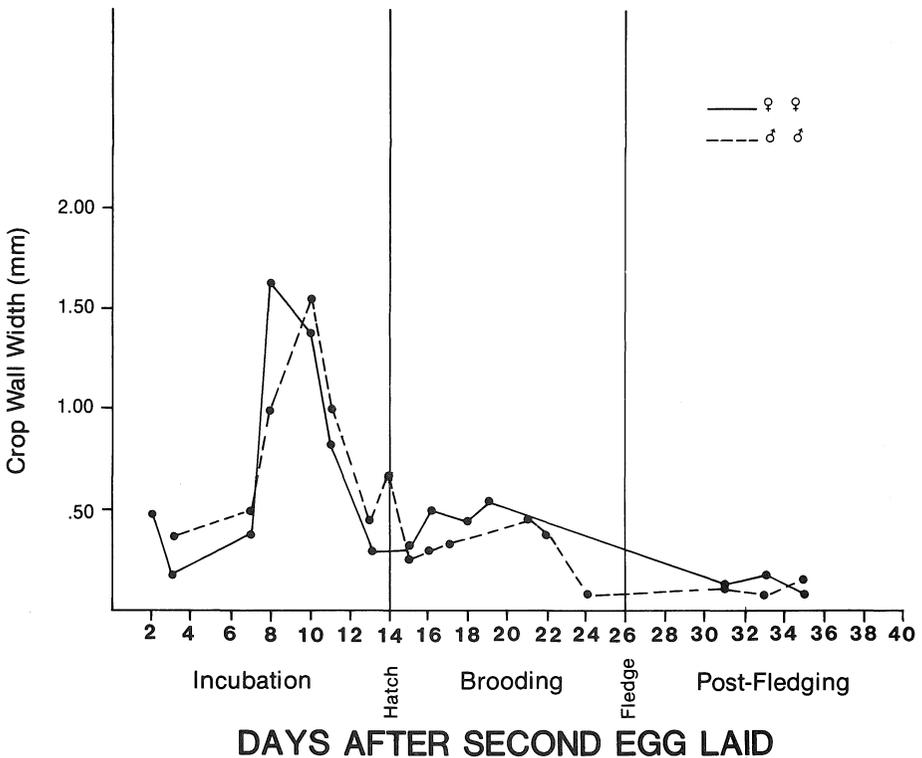


Fig. 4. Maximum crop wall widths related to position in nesting cycle. Plotted points represent data from 1 bird each except as follows: Day 7, female, 2 birds; Day 8, male, 2 birds; Day 19, female, 2 birds; Day 23, male, 2 birds.

vacuoles, and some sloughing of the surface epithelium into the crop lumen was evident.

Day 14 (hatch). The epithelial width was considerably reduced (Fig. 4), and the epithelial folds were taller (Fig. 5).

Days 16-17, female; day 21, male (brooding young). The epithelial folds attained their maximum height at this time (Fig. 5).

Day 18, female; days 21-22, male (brooding young). The stratum basale was distinguishable but ill-defined; the foamy appearance of other epithelial cells persisted, and sloughing of surface cells continued (Fig. 6).

Day 26 (young fledged). The epithelium was still folded and fused, and further sloughing was evident.

Days 29-30 (post-fledging). The epithelium continued to slough, and the lamina propria was extremely vascular. In the female, the stratum basale was again sharply defined and the entire mucosa was thin (Fig. 7). In the male, the stratum basale was not yet well defined and evidences of folding persisted.

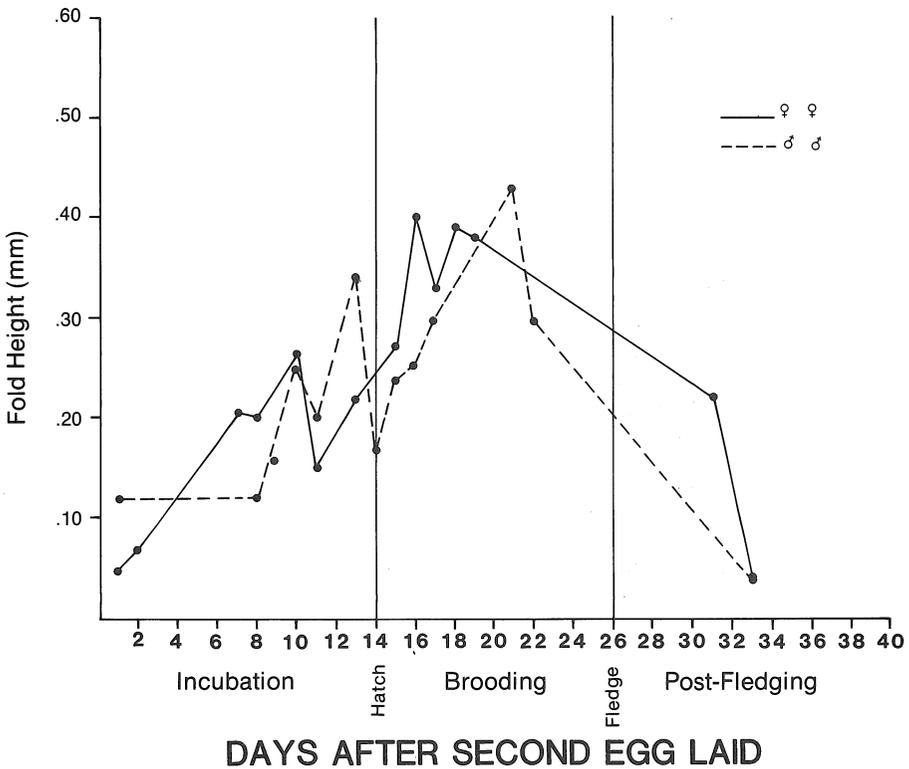


Fig. 5. Maximum epithelial fold heights related to position in nesting cycle. Plotted points represent data from 1 bird each, except as follows: Day 7, female, 2 birds; Day 8, male, 2 birds; Day 21, male, 3 birds.

Day 31, female; Day 33, male (post-fledging). The crop of the female resembled its pre-incubation appearance at Day 31, about 5 days after fledging of young. The male crop did not regain its pre-incubation appearance until about Day 33 (7 days after the young fledged). This is illustrated by a photomicrograph of a crop from a male at Day 33 in which the well-defined stratum basale and many blood vessels in the lamina propria are evident (Fig. 8).

Comparison with Previous Studies

Events in the crop-gland cycle of mourning doves have been described previously by Mirachi and Scanlon (1980, 1982), based on gross morphology of the dissected crop. By histological examination, we perceived onset of crop gland development about 2 days earlier, and the return to the quiescent stage several days later than they did (Table 2). The disparity in crop-gland activity of the 2 sexes appeared to be greater (4-6 days) in their studies than in ours (2 days). Histologic structure may reflect crop-gland development and regression

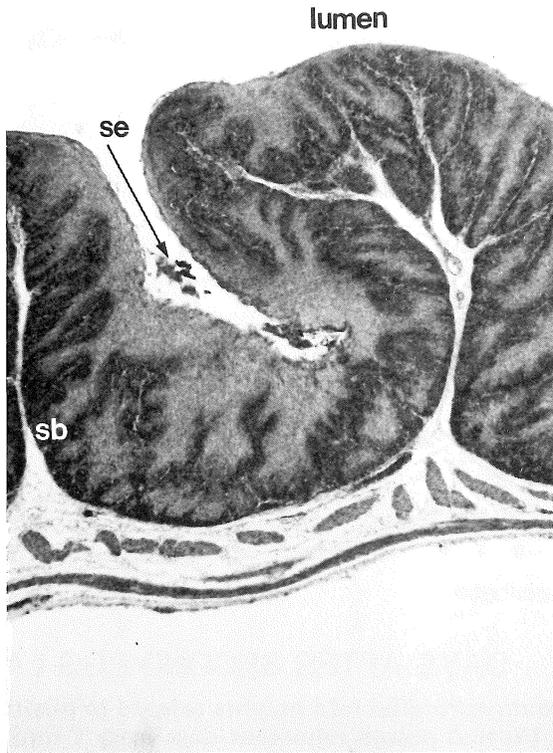


Fig. 6. Cross-section of crop wall of adult female, Day 21 (48x). Note darkly stained, irregularly shaped stratum basale (sb); se = sloughed epithelium.

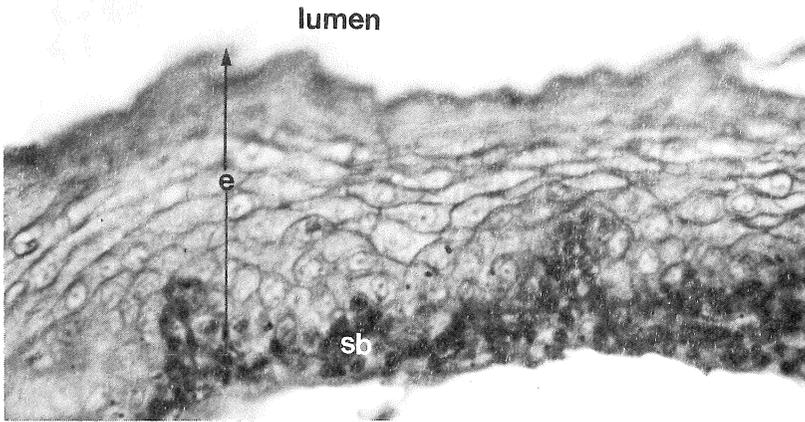


Fig. 7. Cross-section of crop wall of adult female, Day 31 (620x); e = epithelium, sb = stratum basale.

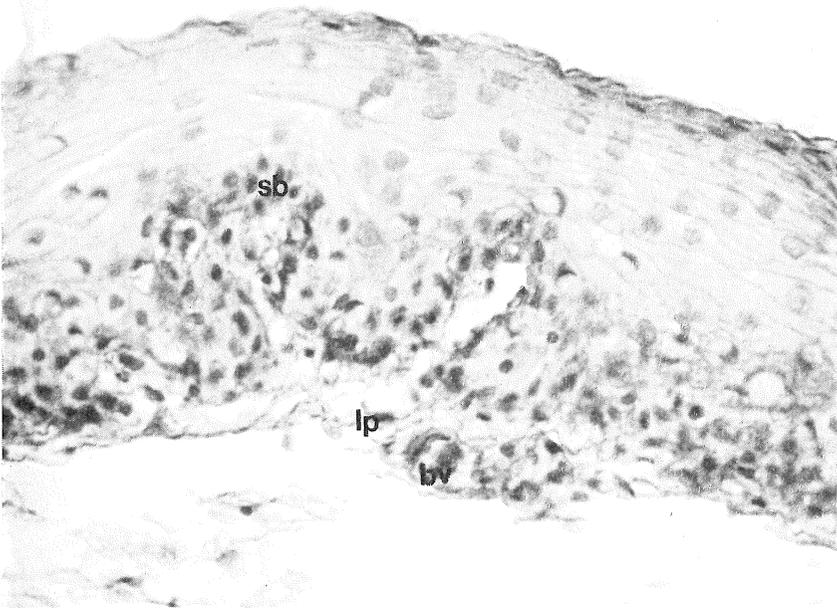


Fig. 8. Cross-section of crop wall of adult male at Day 33 (620x); sb = stratum basale, lp = lamina propria, bv = blood vessel.

Table 2. Events in the nesting cycle and periods of crop-gland activity compared for 4 species of columbids.

Species	Days after last egg laid (source)			
	Incubation period	End of brooding period	Beginning of crop-gland development	Crop-gland regressed
Domestic pigeon (<i>Columba livia</i>)	17-18 (Whitman 1919, Beams and Meyer 1931)	About 38 (Abs 1983)	8 (HS) ¹ (Litwer 1926, Patel 1936, Beams and Meyer 1931)	31-40 (HS) (Beams and Meyer 1931) 43 (HS) (Litwer 1926)
Band-tailed pigeon (<i>Columba fasciata</i>)	19 (Macgregor and Smith 1955)	34-47 (Macgregor and Smith 1955) 40 (Zeigler 1971)	8 (GM) ¹ (Zeigler 1971)	About 50 (GM) (Zeigler 1971)
Ringed turtle-dove (<i>Streptopelia risoria</i>)	14 (Whitman 1919)	28 (Whitman 1919)	8 (CW) ¹ (Lehrman 1964)	32 (CW) (Lehrman 1964)
Mourning dove (<i>Zenaida macroura</i>)	14 (Whitman 1919)	About 26 (Hanson and Kossack 1962)	7 (HS) (This study) About 9 (GM) (Mirarchi and Scanlon 1980, 1982)	Female 31 (HS) Male 33 (HS) (This study) Female 33+ (GM) Male 26+ (GM) (Mirarchi and Scanlon 1980, 1982)

¹Based on: HS - histologic structure, GM - gross morphology and CW - crop weights.

more precisely than gross morphology. However, comparisons must be made cautiously because columbid crop-gland sequences show considerable individual variation, and our sample sizes were small.

Comparison with Other Columbids

The cycle of the mourning dove crop is generally similar to that of other members of the Columbiformes, except for termination and duration of crop-gland activity. For example, band-tailed pigeons have quiescent crops by approximately 30 days after their young hatch (Macgregor and Smith 1955, Zeigler 1971); domestic pigeons by 26 days after hatch (Litwer 1926); ringed turtle-doves by 18 days after hatch (Lehrman 1964); and mourning doves by 17-19 days after hatch (this study).

Of the 4 species compared, the band-tailed pigeon has the longest crop-gland cycle (42 days; Zeigler 1971). While the duration of the crop-gland cycle is similar for the ringed turtle-dove (24 days; Lehrman 1964) and the mourning dove (24-26 days; this study), both have much shorter cycles than the band-tailed pigeon. Duration of crop-gland cycle in the domestic pigeon, about 35 days (Litwer 1926), is intermediate.

Crop-gland activity in the mourning dove began by about 7 days incubation, similar to the other well-studied columbids (Table 2, Fig. 9). Duration and time of termination of crop-gland activity differ in these species, as expected, according to lengths of their breeding cycles. The fully quiescent stage is not reached until several days after young have fledged (Fig. 9), although at this late stage of the cycle the crop serves mainly as a receptacle for seeds and other foods that the parents carry to the young (Moore 1940).

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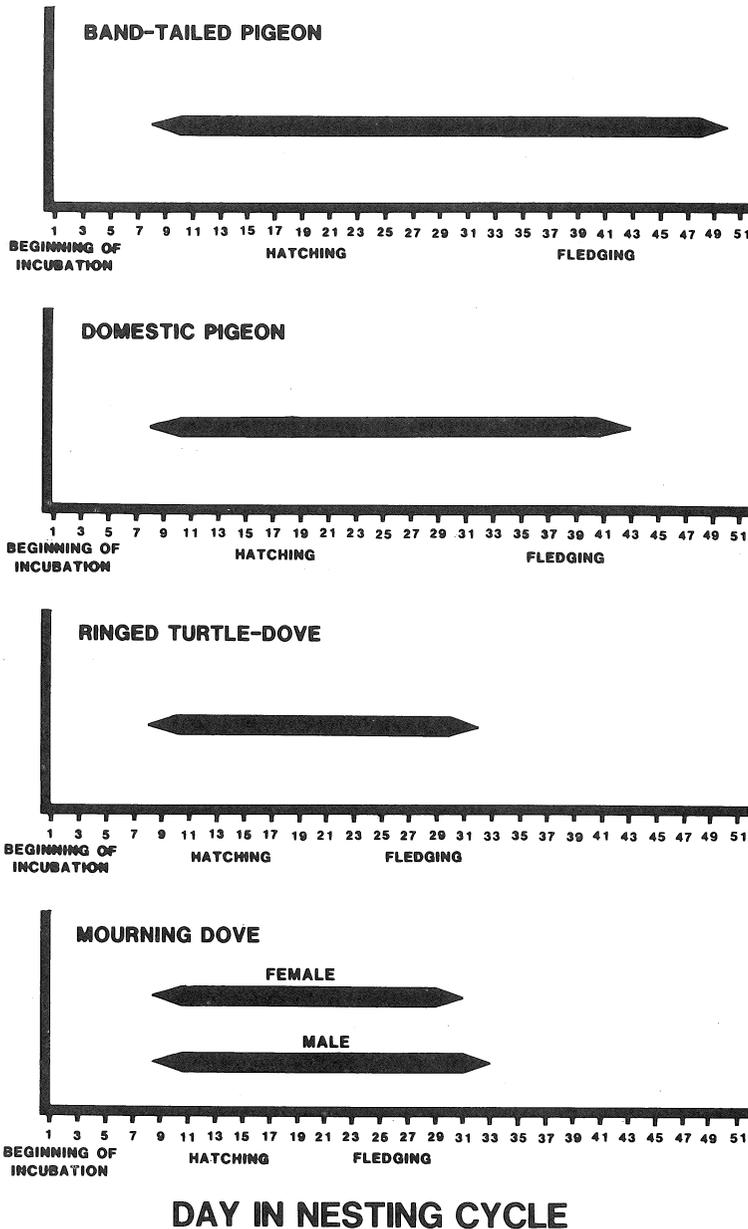


Fig. 9 Periods of crop-gland activity (dark bars) in 4 species of columbids, as related to events in their nesting cycles, based on gross morphology (band-tailed pigeon), histologic structure (domestic pigeon and mourning dove) and crop weights (ringed turtle-dove); for sources, see Table 2.

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Thermal Decomposition of Bis(3-Phenyl-3-Methylbutanoyl) Peroxide

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Abstract: The thermal decomposition of bis(3-phenyl-3-methylbutanoyl) peroxide in isooctane (concentrations between 0.008 and 0.0248 M) was studied over the temperature range from 56.8 to 87.8°C. Values for the energy and entropy of activation for the decomposition were found to be 32 ± 2 Kcal/mole and 9.2 cal/mole degree, respectively. These values compare favorably with the energy and entropy of activation previously reported for thermal decomposition of asymmetric peroxides containing the 3-phenyl-3-methylbutanoyl group.

Key Words: bis(3-phenyl-3-methylbutanoyl) peroxide, thermal decomposition, isooctane

Introduction

The 2-phenyl-2-methyl-1-propyl free radical (neophyl free radical) is one of only a few free radicals that have been shown to undergo rearrangement¹, scheme 1. Several studies have examined the decomposition of peroxides

Scheme 1:



where one of the groups attached to a peroxide oxygen is a 3-phenyl-3-methylbutanoyl or a substituted 3-phenyl-3-methylbutanoyl group² mainly to determine the effect of the substituent upon thermal decomposition rates, and its influence upon rearrangement. We became interested in examining thermal decomposition of the symmetrical peroxide, bis(3-phenyl-3-methylbutanoyl) peroxide or bis(*beta*-phenylisovaleryl) peroxide to determine if this peroxide would exhibit abnormal kinetics for its thermal decomposition that might be explained as anchimeric or steric assistant due to the phenyl ring. We would like to report our findings.

Experimental Methods

Neophyl chloride was prepared in 89% yields from benzene and 3-chloro-2-methylpropene by the method of Smith and Sellas³. Neophyl chloride was converted to 3-phenyl-3-methyl butanoic acid (mp 55-56°C., lit. 53-55°C⁴) via a Grignard reaction of the chloride with carbon dioxide, in 73% yield (ir:

3500-2500, 1710, 760 and 695 cm^{-1} , nmr:⁵ 1.35 singlet (6H), 2.16 singlet (2H), 7.35 singlet (5H), 12.01 singlet (1H)). The acid was converted into the acid chloride (bp:88-9/0.8torr) in 50% yield (ir: 1800, 770, 695 cm^{-1} , nmr: 1.35 singlet (6H), 3.25 singlet (2H), 7.35 singlet (5H)). The method of Rickatson and Stevens⁶ was used to convert the acid into the bisdiacyl peroxide (mp 43°C, lit. 42.5-43.8° C^{1e}) in 80% yields (ir: 1812, 1788, 970, 960 cm^{-1} , nmr: 1.25 singlet (6H), 2.45 singlet (2H), 7.15 singlet (5H)). Overall yields of the peroxide from 3-chloro-2-methylpropene were 26%. The peroxide was found to be $97 \pm 3\%$ pure by iodometric titration.

Decomposition Procedure

Solutions of the peroxide in purified 2,2,4-trimethylpentane were prepared with the peroxide concentration as given in Table 1. The solutions were degassed and immersed in a constant temperature bath maintained within 0.1°C. At various times 1 mL aliquots of the solution were removed. Decomposition was quenched by immersion in a dry ice slush.

Table 1. Kinetics of decomposition of bis(3-phenyl-3-methylbutanoyl) peroxide as a function of temperature, and peroxide concentration. The rate data were obtained by following the decrease in infrared absorption at 1812 cm^{-1} due to the peroxide carbonyl.

Exp. no.	Temp. in °C.	Concentration mole/liter	Points	Rate constant	
				Individual 1/(mol. min. x 10 + 4)	Average
1	52.4	0.0174	12	0.4801	0.4801
2	56.8	0.0010	8	1.571	
3	56.8	0.0136	10	1.333	1.497
4	56.8	0.0248	15	1.539	
5	66.8	0.0135	9	5.329	
6	66.8	0.0202	9	5.397	5.363*
7	66.8	0.0174	16	5.549**	
8	70.5	0.0134	20	5.794	
9	70.5	0.0217	14	6.210	6.002
10	79.2	0.0079	8	30.86	
11	79.2	0.0120	9	30.20	31.30*
12	79.2	0.0235	12	32.83	
13	79.2	0.0280	13	31.75**	
14	87.8	0.0092	14	64.02	
15	87.8	0.0142	18	71.79	66.74
16	87.8	0.0172	17	71.69	

* Average value for the rate of decomposition, excluding the value obtained with added iodine.

** Data obtained with added 0.04 M iodine.

Decomposition kinetics were measured by infrared spectroscopy as previously reported by Tanner⁷. Plots of the log of absorption of the peroxide carbonyl band at 1812 cm⁻¹ as a function of time produced straight line plots. Correlation coefficients for all the plots were better than 0.99. Rate constants were obtained from the slopes of these lines and reported in Table 1. Infrared spectra of the solutions at completion of decomposition showed an absence of any detectable carbonyl absorption.

A plot of the rate constants vs. the reciprocal of the absolute temperature also gave a straight line plot, Fig. 1, with a correlation coefficient of 0.992. From the slope of the plot the value of the energy of activation for the decomposition was determined to be 32 ± 2 Kcal/mole.

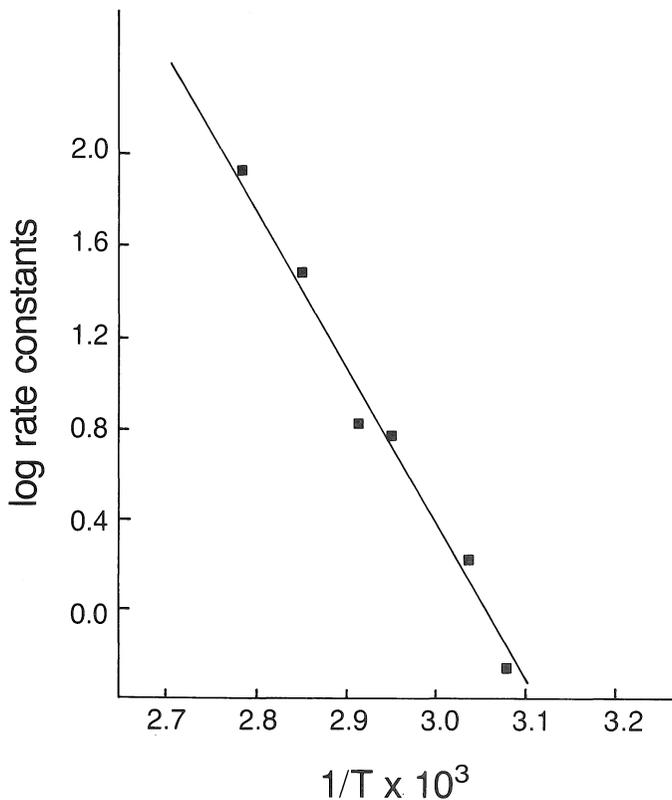


Fig. 1. Arrhenius plot for thermal decomposition of bis(3-phenyl-3-methylbutanoyl) peroxide. The equation for the line is given by $Y = -6957.7X + 21.156$ (corr. coef. 0.992).

Decomposition Products

Using the experiments at 66.8°C, aliquots of the solutions at completion of decomposition had an accurately weighted amount of chlorobenzene added. The solutions were analyzed by GC on a 6' x 1/4 10% SE-30 on 100/120 Chromosorb W glpc column and found to contain *t*-butylbenzene (60±2%) and isobutylbenzene (41±2%). The material balance based upon the peroxide was found to be 98±3%.

Discussion of Results

The rate of decomposition of bis(3-phenyl-3-methylbutanoyl) peroxide was studied in isooctane solutions over a temperature range of 56.8-87.8°C. Decomposition was also carried out at a series of different concentrations (0.008-0.0248 M). In all cases, kinetic data followed the first-order rate law through more than 2 half lives. Values obtained for the kinetics of decomposition are reported in Table 1. The organic products from decomposition were *t*-butylbenzene and isobutylbenzene, both arising from hydrogen abstraction from the solvent. No ester was detected by either glpc or infrared analysis of the reaction mixtures.

Lamb⁸ reported, based upon his study of thermal decomposition of bis(5-hexenoyl) peroxide in toluene, that peroxide concentrations lower than 0.036 M suppress radical induced decomposition⁹. Since our kinetic values were at lower concentration ranges and were within experimental error at a given temperature, the involvement of induced decomposition can be excluded as affecting our data. Furthermore, in decompositions with added iodine, (0.04 M) as a free radical scavenger, experimentally identical values were obtained for the rate constants to those without iodine (Table 1 entries 7 and 13). This result again suggests that induced decomposition is not important in this study. The use of isooctane, a nonpolar solvent would further be expected to suppress induced decomposition, compared to aromatic solvents.

A plot of the log of the rate constants as a function of 1/T gave a straight line (Fig. 1). From the slope, the energy of activation for decomposition of the peroxide was calculated to be 32±2 Kcal/mole (correlation coefficient 0.992). From this value of E_a , and the Arrhenius equation, values for the enthalpy and entropy of activation were calculated to be 31. Kcal/mole and 9.2 cal/mole-degree, respectively. These values compare favorably with those previously obtained for the decomposition of *p*-nitrobenzoyl 3-phenyl-3-methylbutanoyl peroxide by Lamb^{2a} in cyclohexane solutions of 30.05 Kcal/mole and 9.5 cal/mole-degree for the energy and entropy of activation, respectively. These 2 nonpolar solvents would be expected to give similar results.

The value for the energy of activation of decomposition for other symmetric peroxides has been determined, such as diacetyl and dibenzoyl (32.2¹⁰, and 30¹¹ Kcal/mole, respectively) and are again similar to the values for bis(3-phenyl-3-methylbutanoyl) peroxide calculated here¹². Similar values for the energies of activation and entropy of activation to other reported symmetrical and asymmetrical aromatic and aliphatic bis-peroxides would indicate that there is no steric acceleration nor anchimeric assistance to decomposition with bis(3-phenyl-3-methylbutanoyl) peroxide.

Acknowledgment

Acknowledgment is made to the Faculty Development Committee of Missouri Southern State College for a research grant to partially support this project.

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12. Comparison of our results with the earlier data is probably less meaningful, since concentration ranges for the peroxide used in these earlier studies is at the level where induced decomposition has been noted (3). Induced decomposition would be expected to give higher than actual values for the kinetics.

Solar Radiation in Southeast Missouri

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Abstract: The daily solar radiation on a horizontal surface has been measured in Cape Girardeau, MO, since October 1980. Monthly and annual averages of the daily radiation and clearness index have been computed and are compared to the long-term values reported by National Weather Service stations at Columbia, MO, and Nashville, TN. Annual averages were found to vary by only $\pm 3\%$ with a 3-year mean value of $14.4 \pm 0.4 \text{ MJ/m}^2$ for the daily solar radiation and a value of 0.50 ± 0.01 for the clearness index. These results are quantitatively the same as those obtained by extrapolation of the long-term values from Columbia and Nashville. It was found that on a monthly basis geographical variation of solar radiation among the 3 sites is minor, except for a possible 10% reduction at Cape Girardeau relative to Columbia during the summer months. Using a theoretical model, daily solar radiation on a south-facing tilted surface was calculated as a function of tilt angle. The annual average had a maximum value of 16.0 MJ/m^2 on a surface tilted at an angle approximately equal to the latitude, and the winter average for the months November through March had a maximum value of 13.5 MJ/m^2 on a surface tilted at an angle approximately equal to the latitude plus 15° .

Key Words: Solar radiation, solar energy, Missouri meteorological, meteorological

Introduction

Solar radiation is a meteorological parameter which is of interest to scientists in a wide variety of disciplines. Because of the national need for reliable long-term solar radiation data, the federal government instituted a program in the 1970's to upgrade the quality of its radiation measuring stations and to rehabilitate past data to account for sensor deterioration and calibration errors. This project resulted in the most accurate known data base for solar radiation which consists of both hourly and daily data, referred to as the SOLMET and SOLDAY studies, respectively.^{1,2} Statistical summaries of these government studies have been carried out and are available on tape and in tabular form.^{3,4}

Although the solar resource is better quantified at the present time than it was 10 years ago (primarily because of the SOLMET and SOLDAY studies), the rapid growth of solar energy research and applications illustrates a need for greater geographical density of solar radiation measurement sites. One recent study has concluded that the existing solar radiation data network provides very inadequate spatial coverage for daily values with an error tolerance of $\pm 10\%$ at a 90% confidence level.⁵

This paper presents results of the continuous monitoring of solar radiation in Cape Girardeau, MO, since October 1980. The purpose of the study was to investigate solar energy availability at this location, which represents the only site in Missouri (except Columbia) where solar radiation is measured. This site is 1 of approximately 100 such sites in the entire country.⁶

Experimental Procedure

For each day over the period of record from 10/1/80 to 12/31/83, the solar radiation on a horizontal surface was measured and recorded with a pyranometer, electronic integrator, chart recorder and microcomputer. The instrumentation was located in Magill Hall on the campus of Southeast Missouri State University at latitude $37^{\circ}18'56''$ N and longitude $89^{\circ}31'45''$ W. An Eppley model 8-48 pyranometer was mounted horizontally at an elevation of 522 ft on the roof of the building such that the sky dome seen by the pyranometer was unobstructed in all directions, except within a narrow region from 0 - 5° above the horizontal due to the presence of some tall trees and buildings. The effect of the obstructions on daily solar radiation was less than 1%, since the contribution to horizontal solar radiation is approximately proportional to the sine of the solar elevation which is small at low sun angles. The pyranometer was periodically returned to the manufacturer for recalibration, since constant exposure to the elements produced changes in the pyranometer sensitivity. Two pyranometers with sensitivities of approximately $10 \mu\text{V}/(\text{W}/\text{m}^2)$ were used to provide a continuous record. The analog signal from the pyranometer was monitored with a chart recorder and integrated by an Eppley model 410 electronic integrator. A Rockwell AIM 65 microcomputer digitized and stored the integrated signal and printed out the cumulative solar radiation at preset time intervals.

Data Analysis

Monthly and annual averages of the daily solar radiation on a horizontal surface, \bar{H} , are given in Table 1. The small variations of $\pm 3\%$ in the annual means are not surprising and are an indication of the relative constancy of ground-level solar radiation on a yearly basis. The 3-year mean value of $14.39 \pm 0.39 \text{ MJ}/\text{m}^2$ for the daily solar radiation in Cape Girardeau agrees quite well with the 24-year mean values reported in the SOLMET study for the 2 nearest locations: $15.07 \text{ MJ}/\text{m}^2$ in Columbia, MO, and $14.41 \text{ MJ}/\text{m}^2$ in Nashville, TN.⁴ Cape Girardeau lies along a line between Columbia and Nashville at a point approximately 180 miles equidistant from each. The variation of solar radiation due to a latitude difference along this line is small since the latitude difference is at most 3° . A comparison of annual means of the theoretical solar radiation that would be received on a horizontal plane in the absence of an atmosphere shows a variation of less than 3% along the line from Columbia to Nashville. Thus any differences in long-term solar radiation at sites along this line should be primarily due to atmospheric effects, either weather phenomena such as clouds, fog, etc. or turbidity from anthropogenic air pollution.

Fig. 1 illustrates the geographic variation of daily solar radiation on a monthly basis. Again the agreement is quite good although solar radiation in Cape Girardeau during the summer months appears to be about 10% less than that at Columbia. If this summer anomaly persists over the long term in Cape Girardeau, it would indicate that atmospheric conditions (cloudiness, haziness or both) are different from those in Columbia. (This conclusion also assumes that the radiation sensor is located at a site where there are no local sources of air pollution. This was confirmed qualitatively by visual observation but could not

Table 1. Monthly and annual mean daily solar radiation \bar{H} in Cape Girardeau, MO (MJ/m²).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1980	—	—	—	—	—	—	—	—	—	13.99	9.48	7.38	—
1981	8.96	11.09	16.14	18.85	17.06	19.82	18.96	18.10	17.41	11.18	8.09	7.10	14.40
1982	7.36	10.35	14.77	17.70	21.56	21.69	22.14	19.25	16.85	12.76	7.15	5.32	14.77
1983	6.53	10.06	12.25	13.54	19.41	22.63	23.20	21.53	17.23	10.19	6.66	4.42	13.99
3-year mean ^a	7.62	10.50	14.39	16.70	19.34	21.38	21.43	19.63	17.16	12.03	7.85	6.06	14.39 ± 0.39

^aData for Oct-Dec are 4-year means.

Table 2. Three-year monthly and annual mean daily solar radiation \bar{H} , extraterrestrial radiation \bar{H}_o ^a and clearness index \bar{K}_T in Cape Girardeau, MO (latitude = 37.3°N).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
\bar{H} (MJ/m ²)	7.62	10.50	14.39	16.70	19.34	21.38	21.43	19.63	17.16	12.03	7.85	6.06	14.39±0.39
\bar{H}_o (MJ/m ²)	16.70	21.84	28.35	34.96	39.47	41.25	40.29	36.63	30.69	23.71	17.88	15.27	28.92
$\bar{K}_T = \bar{H}/\bar{H}_o$	0.456	0.481	0.507	0.477	0.490	0.519	0.532	0.536	0.559	0.508	0.439	0.396	0.498±0.013

^aBased on a solar constant of 1353 W/m² (see Appendix A).

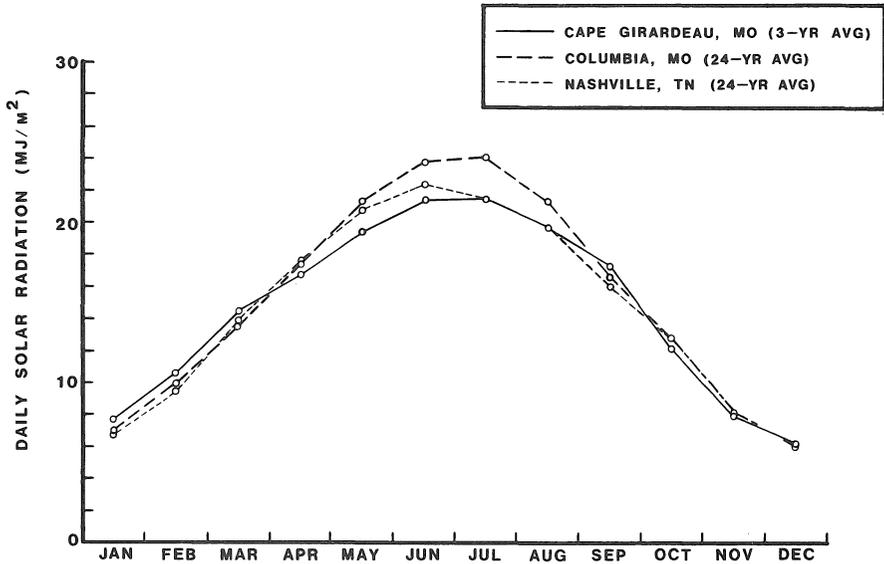


Fig. 1. Geographic comparison of average daily solar radiation on a horizontal surface for each month. Data for Cape Girardeau are monthly averages for the period Oct 1980-Dec 1983 from Table 2 of this study. Data for Columbia and Nashville are for the period Jul 1952-Dec 1975 from Ref. 4.

be quantified due to the lack of a second pyranometer with which to take measurements at several sites in the Cape Girardeau area.) A possible explanation for this summer anomaly may be an increasing atmospheric turbidity in an eastern direction from Columbia. Husar et al.⁷ have noted the existence of a broad region of atmospheric haziness centered in the Tennessee-Ohio River basin thought to be due to emissions from coal-fired electric power plants. This so-called "eastern haze" has a seasonal dependence, being most pronounced in the warm summer months during periods of high relative humidity.

It is convenient to compare the ground-level solar radiation to that which would be received if there were no atmosphere. Appendix A outlines the method used to compute the daily extraterrestrial solar radiation on a horizontal surface, H_0 , and its monthly average, \bar{H}_0 .⁸ The monthly average clearness index, \bar{K}_T , is then defined to be

$$\bar{K}_T = \bar{H}/\bar{H}_0 \quad (1)$$

The range of this ratio is $0 < \bar{K}_T < 1$ since it represents the fraction of solar radiation transmitted through the atmosphere and, thus, is a measure of cloudiness and atmospheric turbidity. Table 2 presents the 3-year monthly and annual values of \bar{H} , \bar{H}_0 and \bar{K}_T in Cape Girardeau over the period of record. The 3-year mean value of 0.498 ± 0.013 for the clearness index in Cape Girardeau can be compared with the 24-year mean values at Columbia and Nashville of 0.52 and 0.48, respectively.⁴ As noted previously, the latitudinal

variation of \bar{H}_o , and consequently of \bar{K}_T , will be minor among the 3 sites. Hence any differences in the long-term clearness indexes will represent differences in atmospheric transmission of solar radiation.

Solar Radiation on a Tilted Surface

Appendix B develops the method used to compute \bar{H}_T , the monthly average daily solar radiation on a south-facing tilted surface.^{9,10} Such information is necessary for many types of solar energy design applications. Lack of duplicate instrumentation prevented \bar{H}_T from being measured in this study; however Klein⁸ has shown that values of \bar{H}_T computed with this method are within 5-10% of the experimental values. Eq. (B2) gives $\bar{H}_T = \bar{H}\bar{R}$ so that \bar{R} , in effect, is a multiplying factor. Examination of Eqs. (A2, A3, B3-B6) shows that \bar{R} is a function of the tilt angle s , latitude ϕ , ground reflectance ρ , and clearness index \bar{K}_T . Combining Eqs. (1) and (B2) gives for the daily solar radiation on a south-facing tilted surface

$$\bar{H}_T = \bar{H}\bar{R} = \bar{K}_T\bar{H}_o\bar{R}(s, \phi, \rho, \bar{K}_T) \quad (2)$$

Fig. 2 shows the results of calculations of \bar{H}_T for various tilt angles using

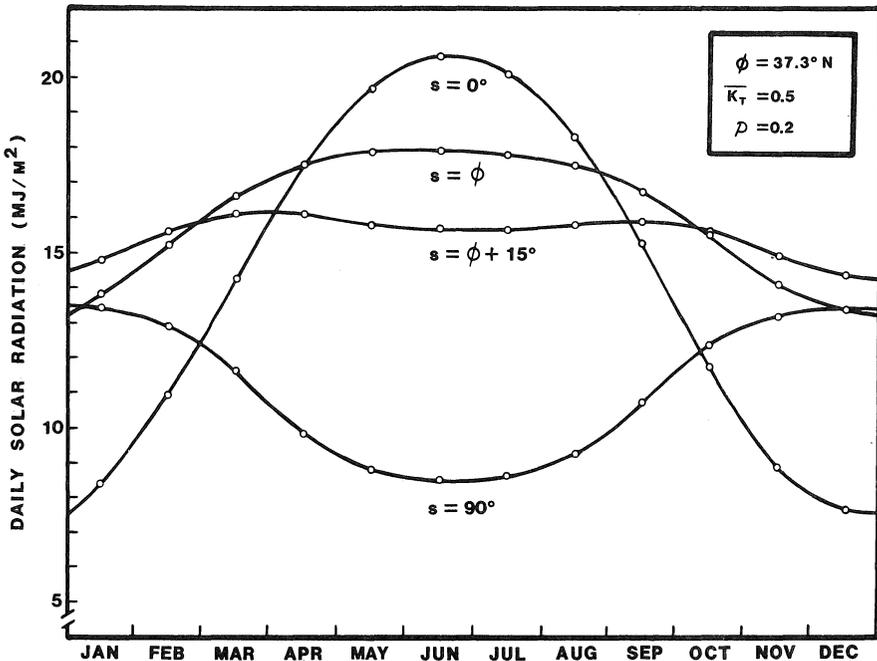


Fig. 2. Average daily solar radiation on south-facing tilted surfaces for each month. The curves are based on a theoretical model discussed in the text with model parameters appropriate for Cape Girardeau, MO, i.e. latitude $\phi = 37.3^\circ\text{N}$, clearness index $\bar{K}_T = 0.5$ for each month and ground reflectance $\rho = 0.2$ with no snow cover. Results are shown for 4 tilt angles from $s = 0^\circ$ (horizontal) to $s = 90^\circ$ (vertical).

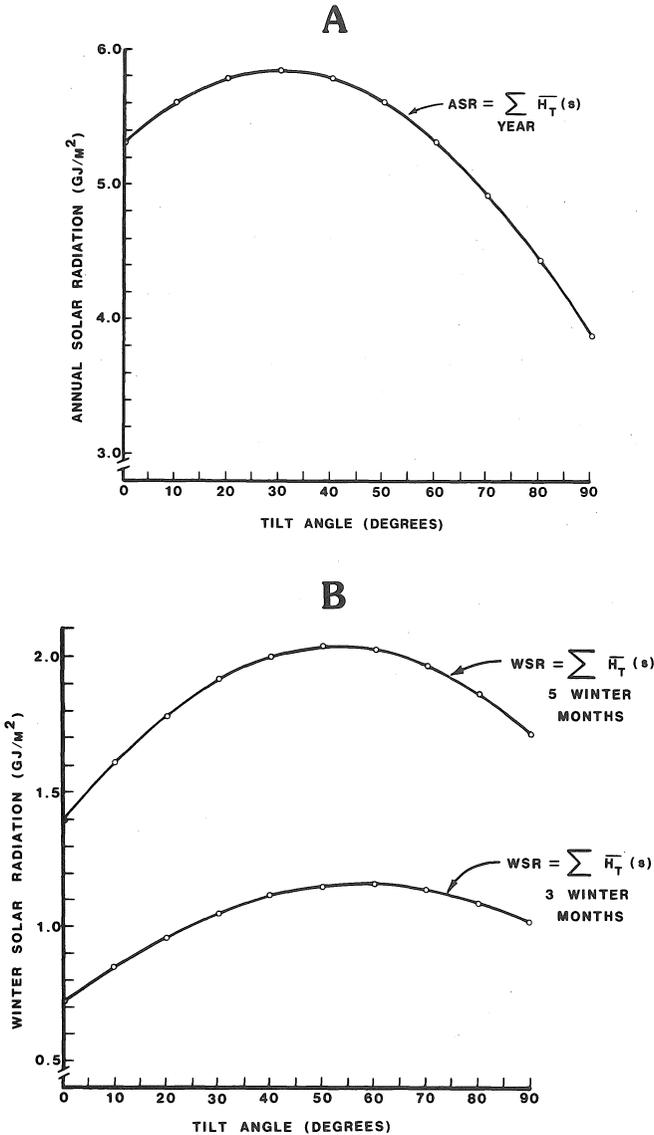


Fig. 3. Annual (a) and winter (b) solar radiation on south-facing tilted surfaces versus tilt angle. The curves are based on a theoretical model with parameters appropriate for Cape Girardeau, MO, ($\phi = 37.3^\circ\text{N}$, $\rho = 0.2$, \bar{H} and \bar{K}_T from Table 2). Each graph was computed by a summation of curves of the type shown in Fig. 2 over all (a) or part (b) of a year. The top curve in (b) was computed for the 5 months Nov-Mar and the bottom curve for the 3 months Dec-Feb.

parameters appropriate for Cape Girardeau. Rather than use the experimental values of \bar{K}_T from Table 2, the annual average of 0.50 was used in order to make the curves appear more regular, although perhaps not as realistic. A ground reflectance value of $\rho=0.2$ was assumed in accordance with the comments made in Appendix B.¹¹ The effect of receiving surface orientation on the incident radiation is clearly demonstrated: increasing the slope of the surface produces an increase in wintertime radiation and a decrease in summertime radiation.

Annual and seasonal solar radiation on tilted surfaces can be readily calculated by performing the appropriate monthly summations on \bar{H}_T . This process amounts to approximate integration of the curves shown in Fig. 2 over all or part of a year. Fig. 3 shows the results of the calculation using parameters appropriate for Cape Girardeau. The experimental values of \bar{H} and \bar{K}_T from Table 2 were used to calculate \bar{H}_T in Fig. 3, rather than assuming a constant value of $\bar{K}_T = 0.5$ and $\bar{H} = 0.5 \bar{H}_o$ as was done in Fig. 2. Fig. 3(a) indicates that the annual solar radiation on a tilted surface is maximized at 5.84 GJ/m² over a range of angles centered approximately at the latitude. Fig. 3(b) shows winter solar radiation on a tilted surface for the months November-March (top curve) and for the months December-February (bottom curve). The 5 months used in the top curve represent the time of year when 85% of the heating load occurs in Missouri. For these months the winter solar radiation is maximized at 2.04 GJ/m² over a range of angles centered approximately at latitude plus 15°. The 3-month curve represents the time of year when 60% of the heating load occurs in Missouri and is shown only for comparison; its peak is shifted to a greater tilt angle since the average solar zenith angle will be greater during this time period. It is convenient to express the maximum annual and winter solar radiation totals as daily values by dividing by the number of days. This yields an annual value of 16.0 MJ/m² on a south-facing surface tilted at an angle $s \approx \phi$ and a winter value of 13.5 MJ/m² on a south-facing surface tilted at an angle $s \approx \phi + 15^\circ$, both of which can be compared to the value on a horizontal surface of 14.4 MJ/m².

Some general comments can be made concerning the above results. First, the curves in Fig. 3 show broad maxima indicating relative insensitivity to tilt angle, i.e. variations of as much as $\pm 15^\circ$ in the optimum slope produce less than a 5% decrease in the radiation received. Similar studies have confirmed these results and, additionally, have shown that surfaces facing 20-30° east or west of south have minimal effect on the annual radiation received.¹² Second, the foregoing results represent an upper limit to the solar radiation incident on a tilted surface, unless the reflected component is increased either by snow cover or by employing artificial reflectors. Finally, solar energy systems convert radiation to some other type of energy and many other factors must be taken into account to determine the useful energy collected.

Results and Conclusions

Solar radiation measurements over a 3-year period in Cape Girardeau, MO, indicate that there is little year-to-year variation in the terrestrial sunlight

received. Comparison of these measurements with long-term data from weather service stations at Columbia, MO, and Nashville, TN, show only minor geographic variations on a monthly and annual basis. The greatest observed difference occurs during the summer months when solar radiation in Cape Girardeau is about 10% less than that at Columbia. Further research is needed to determine if this effect is a result of differences in cloudiness or atmospheric turbidity due to air pollution. A theoretical model was used to compute the solar radiation on south-facing tilted surfaces. It was found that the incident energy was a maximum for year-round applications (such as water heating) on a surface tilted at an angle equal to the latitude ($\approx 37^\circ$ in Cape Girardeau), and a maximum for wintertime applications (such as space heating) on a surface tilted at an angle equal to the latitude plus 15° ($\approx 52^\circ$ in Cape Girardeau).

Appendix A Calculation of \bar{H}_o

The daily extraterrestrial solar radiation on a horizontal surface, H_o , is given by Klein⁸ to be

$$H_o = \frac{24 \times 3600 G_{sc}}{\pi} \left[1 + 0.033 \cos \left(\frac{360n}{365} \right) \right] \times \left[\cos \phi \cos \delta \sin \omega_s + \frac{2 \pi \omega_s}{360} \sin \phi \sin \delta \right] \quad (A1)$$

where H_o has units of J/m^2 , $G_{sc} = 1353 \text{ W/m}^2$ is the solar constant, n is the day of the year ($n=1$ for January 1), ϕ is the latitude (positive for northern hemisphere), δ is the solar declination,

$$\delta = 23.45^\circ \sin \left[\frac{360(n + 284)}{365} \right] \quad (A2)$$

ω_s is the sunrise hour angle for the horizontal surface,

$$\omega_s = \cos^{-1} (-\tan \phi \tan \delta) \quad (A3)$$

and all the angles are expressed in degrees. The value of 1353 W/m^2 for the solar constant is the so-called NASA standard used in many solar energy reference texts (such as Ref. 12); more recent satellite measurements¹³ have revised this value to 1367 W/m^2 . It can be seen from Eq. (A1) that H_o is a function only of day of the year and latitude, and can be summed to give a monthly average

$$\bar{H}_o(\phi) = \frac{1}{(m_2 - m_1 + 1)} \sum_{n=m_1}^{m_2} H_o(n, \phi) \quad (A4)$$

where m_1 and m_2 are the days of the year at the beginning and end of the

month. An alternative simpler method for calculating \bar{H}_o for each month (accurate to 1%) is to use Eq. (A1) with the value of n for which H_o is as close as possible to \bar{H}_o for the month. These so-called "representative days" of the month are given in Table 3.

Table 3. Representative days of each month for which $H_o = \bar{H}_o$.

Month	$n = \text{day of the year}$	Date
Jan	17	Jan 17
Feb	47	Feb 16
Mar	75	Mar 16
Apr	105	Apr 15
May	135	May 15
Jun	162	Jun 11
Jul	198	Jul 17
Aug	228	Aug 16
Sep	258	Sep 15
Oct	288	Oct 15
Nov	318	Nov 14
Dec	344	Dec 10

Appendix B Calculation of \bar{H}_T

The method of Liu and Jordan⁹ was used to calculate \bar{H}_T , the monthly average daily solar radiation on a south-facing tilted surface. (Klein⁸ extends the method of Liu and Jordan to a surface of any orientation.) \bar{H}_T can be thought of as the sum of the beam, diffuse and ground-reflected components of solar radiation incident on the tilted surface. If the diffuse and reflected radiation are assumed to be isotropic, then \bar{H}_T can be represented by

$$\bar{H}_T = \bar{R}_b (\bar{H} - \bar{H}_d) + \left[\frac{1 + \cos s}{2} \right] \bar{H}_d + \rho \left[\frac{1 - \cos s}{2} \right] \bar{H} \quad (\text{B1})$$

where \bar{R}_b is the ratio of the average daily beam radiation on the tilted surface to that on a horizontal surface, \bar{H} is the monthly average daily radiation on a horizontal surface, \bar{H}_d is the monthly average daily diffuse radiation on a horizontal surface, s is the (south-facing) tilt angle of the surface from the horizontal and ρ is the ground reflectance. Factoring \bar{H} out from each term in Eq. (B1) gives

$$\bar{H}_T = \bar{H} \bar{R} \quad (\text{B2})$$

where

$$\bar{R} = \bar{R}_b \left[1 - (\bar{H}_d/\bar{H}) \right] + \left[\frac{1 + \cos s}{2} \right] (\bar{H}_d/\bar{H}) + \rho \left[\frac{1 - \cos s}{2} \right] \quad (B3)$$

For surfaces sloped toward the equator in the northern hemisphere, \bar{R}_b can be approximated by

$$\bar{R}_b \approx \frac{\cos(\phi-s) \cos \delta \sin \omega'_s + (\pi/180) \omega'_s \sin(\phi-s) \sin \delta}{\cos \phi \cos \delta \sin \omega_s + (\pi/180) \omega_s \sin \phi \sin \delta} \quad (B4)$$

where ω'_s is the sunrise hour angle for the tilted surface

$$\omega'_s = \min \left[\omega_s, \cos^{-1} (-\tan(\phi-s) \tan \delta) \right] \quad (B5)$$

and the other quantities have been defined in Appendix A. The original Liu and Jordan correlation for \bar{H}_d/\bar{H} has been improved upon by Collares-Pereira and Rabl¹⁰ and is given as

$$\bar{H}_d/\bar{H} = 0.775 + 0.00606 (\omega_s - 90^\circ) - \left[0.505 + 0.00455 (\omega_s - 90^\circ) \right] \cos(115\bar{K}_T - 103^\circ) \quad (B6)$$

Finally, the ground reflectance ρ depends on the surroundings and may vary from a low value of 0.1 for weathered blacktop to a high value of 0.75 for fresh snow. Hunn and Calafell¹¹ suggest that values from 0.2 to 0.4 are appropriate for residential landscapes with no snow cover.

For a given location, specified by latitude ϕ , the method of determining \bar{H}_T is as follows for each month:

1. Obtain \bar{H} from published tables or maps such as Ref. 4, or if in Missouri data from this work can be used.
2. Calculate the angles δ , ω_s and ω'_s from Eqs. (A2, A3, B5) using the representative day of the month from Table 3.
3. Calculate \bar{H}_o from Eq. (A1) using the representative day.
4. Calculate $\bar{K}_T = \bar{H}/\bar{H}_o$.
5. Calculate \bar{R}_b and \bar{H}_d/\bar{H} from Eqs. (B4, B6).
6. Calculate \bar{R} from Eq. (B3).
7. Calculate $\bar{H}_T = \bar{H} \bar{R}$.

Nomenclature

An overbar indicates a monthly average of a quantity. For example, \bar{H} is the monthly mean of H , the daily solar radiation on a horizontal surface.

- ASR Annual solar radiation on a south-facing tilted surface.
- G_{sc} Solar constant, i.e. the solar radiation outside the earth's atmosphere on a surface perpendicular to the sun's rays at the mean earth-sun distance (see Appendix A).
- H Daily solar radiation on a horizontal surface, the sum of the solar beam plus diffuse components, $H = H_b + H_d$.

H_b	Daily beam solar radiation on a horizontal surface.
H_d	Daily diffuse (sky-scattered) solar radiation on a horizontal surface.
H_o	Daily extraterrestrial solar radiation on a horizontal surface, i.e. the solar radiation that would be received in the absence of an atmosphere.
H_T	Daily solar radiation on a south-facing tilted surface.
K_T	Daily clearness index, i.e. the ratio of the measured solar radiation to the theoretical value it would have in the absence of an atmosphere, $K_T = H/H_o$ ($0 < K_T < 1$).
m_1, m_2	Days of the year at the beginning and end, respectively, of a particular month (for December, $m_1 = 335$ and $m_2 = 365$).
n	Julian day of the year ($n = 1$ for January 1).
R	Ratio of solar radiation on a tilted surface to that on a horizontal surface, $R = H_T/H$.
R_b	Ratio of the beam solar radiation on a tilted surface to that on a horizontal surface, $R_b = H_{bT}/H_b$.
s	Angle between a tilted surface and the horizontal ($0 \leq s \leq 90^\circ$).
WSR	Winter solar radiation on a south-facing tilted surface.
δ	Solar declination, i.e. the angle between the earth-sun line and the earth's equatorial plane ($-23.45^\circ \leq \delta \leq 23.45^\circ$).
ρ	Ground reflectance or surface albedo, i.e. the ratio of the ground-reflected solar radiation to the incident solar radiation ($0 < \rho < 1$).
ϕ	Geographic latitude, north positive ($-90^\circ \leq \phi \leq 90^\circ$).
ω_s	Sunrise hour angle for a horizontal surface, i.e. the angle between the local meridian and the solar meridian at sunrise ($0 \leq \omega_s \leq 180^\circ$).
ω'_s	Sunrise hour angle for a tilted surface, i.e. the angle between the local meridian and the solar meridian at sunrise on the tilted surface ($0 < \omega'_s < 180^\circ$, $\omega'_s < \omega_s$).

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Correlation of the St. Laurent Formation (Middle Devonian) Near Belgique in Northern Perry County, Missouri

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Abstract: The lower beds of the St. Laurent Formation (Middle Devonian) near Belgique, MO, occur in an isolated fault block and contain a unique megafauna along with some conodonts. The conodont fauna includes *Icriodus angustus*, *Icriodus latericrescens* n. subsp. A, *Icriodus symmetricus*, *Paltodus* sp., *Polygnathus pennata*, *?Prioniodina* sp., and *?Prioniodus* sp. The specimens of *Paltodus* and *?Prioniodus* are reworked. Of these species, *I. angustus* occurs in the upper Onondagan and lower to middle Hamilton; *I. latericrescens* n. subsp. A is an Onondagan species in southern Illinois, but extends upsection into the Marcellus in southern Indiana; while *I. symmetricus* and *P. pennata* are common Hamilton/Tully species which also occur in the Lingle Formation (Middle Devonian) in southern Illinois. The conodonts overall indicate a late Eifelian age for the lower of these strata, as does the megafossil *Hexagonaria* aff. *H. coalita*.

Key Words: correlation, Middle Devonian, conodonts, Missouri

Introduction

The St. Laurent Limestone was named by Stuart Weller (1928) from steeply-dipping, generally medium-bedded, dense, gray to bluish-gray or dark gray limestones with interbedded cherty, dolomitic, crinoidal, arenaceous and brecciated limestones, the latter near the base. These strata crop out along St. Laurent Creek in northwestern Perry County, MO (CNI/2 SW $\frac{1}{4}$ and CE $\frac{1}{2}$ SW $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 9, T.36N., R.10E., see Fig. 1). The St. Laurent is gradational with the underlying Beauvais Sandstone (late Eifelian) where the latter is present, and apparently conformable with the underlying Grand Tower Limestone (middle to late Eifelian) where the Beauvais is absent. The St. Laurent is unconformably overlain by the Grassy Creek Shale (Upper Devonian), Fern Glen Formation (Middle Mississippian) and by sandstone blocks which are probably from the Bushberg Formation (Upper Devonian) (Koenig 1961). At some localities in Missouri, the St. Laurent is in fault relationships with overlying Mississippian strata and with underlying Ordovician strata. The St. Laurent is upper Middle Devonian (Givetian) in age, and is stratigraphically equivalent to the Lingle Limestone (late Eifelian to middle Givetian) of southern Illinois. The thickness of the St. Laurent has been measured at about 275 feet at the type section along St. Laurent Creek. The outcrops of the St. Laurent in east central Missouri are confined to a few small fault blocks in Ste. Genevieve and Perry counties within the Wittenberg Trough and the Ste. Genevieve Fault System, except for a few small areas of outcrop near Rolla.

In northern Perry County, 2 miles southwest of Belgique (NW $\frac{1}{4}$ NE $\frac{1}{4}$ SW $\frac{1}{4}$ Sec. 23, T.36 N., R.11 E.; see Fig. 1), about 75 feet of St. Laurent Limestone is

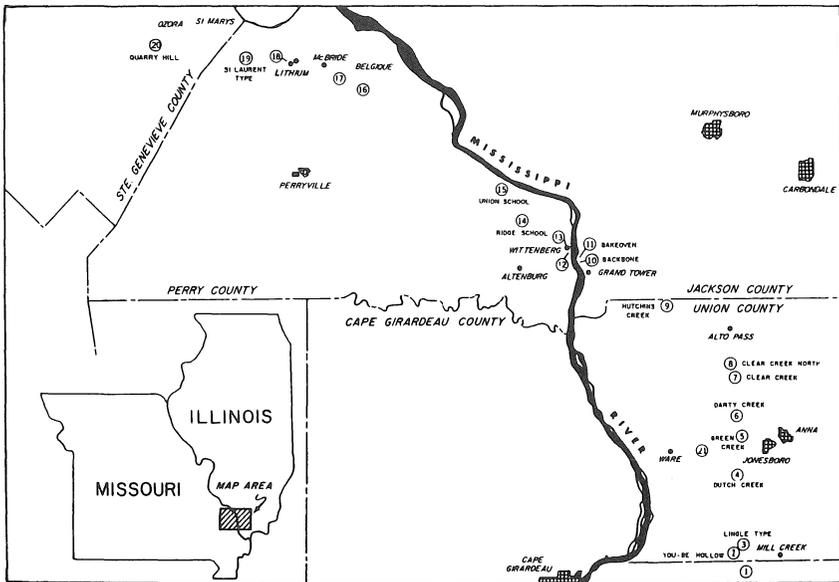


Fig. 1. Locality map of measured sections-St. Laurent type, #19, Belgique, #16.

exposed in a small fault block in the western bluff of the Mississippi River along the west side of the Burlington Northern Railroad tracks. Here the St. Laurent contact with the underlying Grand Tower Limestone is not exposed and the overlying beds have been eroded. In this section, the St. Laurent contains a megafauna that differs from megafaunas found elsewhere in the St. Laurent, which makes this block difficult to correlate with other fault blocks containing the St. Laurent Limestone. The megafauna in the Belgique section includes elements such as *Cyrtina* aff. *dariensis*, which is found in the St. Laurent in this section only and not in the Lingle Limestone. *Hexagonaria* aff. *coalita* (Fraunfelter 1970), which was first described from a quarry at Rogers City, MI, has not been found elsewhere in the St. Laurent or in the Lingle. Longer ranging forms such as *Atrypa imbricaria* and *Retichonetes tumidellus* (Fraunfelter and Baesemann 1972), which occur in the St. Laurent and Lingle at other localities in the area, are also common in the Belgique section. These latter species, however, are not useful as stratigraphic indicators. *Hexagonaria* aff. *coalita* was first found in either the Dundee Formation (Upper Onondagan) or the Rogers City Formation (Marcellus). At both localities, the Belgique section in northern Perry County, MO, and the quarry at Rogers City in northeastern Presque County, MI, *H. aff. coalita* was found in float blocks. The guide fossil for the lower St. Laurent, *Microcyclus discus* (Fraunfelter 1981), is not known from the Belgique section, as are other megafossils characteristic of the lower part of the formation in adjacent areas. As a consequence, at least the lower part of the St. Laurent in the Belgique section may be older than the *Microcyclus* zone, laterally equiva-

lent to it, and/or stratigraphically equivalent to the Beauvais Sandstone which occurs just above the Onondagan/Hamilton boundary, based upon the occurrence of megafossils.

In order to better establish the stratigraphic position and age of the Belgique section of the St. Laurent formation, the section was sampled for conodonts. While the number of conodonts collected from this section was not large, about 2 dozen specimens, conodonts were obtained from all samples collected from the bottom to the top of the section. The conodonts identified from the samples were *Icriodus* n. subsp. A (Klapper and Ziegler 1967), *Icriodus symmetricus*, *Icriodus angustus*, *Polygnathus pennata* (Orr 1964), *?Prioniodina* sp., *Paltodus* sp., and *?Prioniodus* sp. Specimens of the latter 2 genera are reworked. The distribution of these species is shown on the columnar section (see Fig. 2).

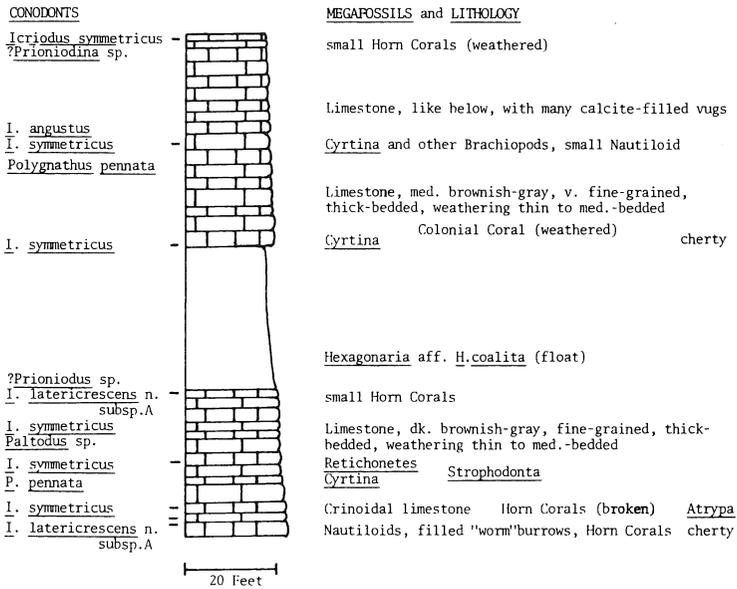


Fig. 2. Columnar section of St. Laurent at Belgique.

Of these conodont species, *I. angustus* occurs in the upper Onondagan and Marcellus (lower Hamilton), *I. latericrescens* n. subsp. A is an Onondagan species in southern Illinois, but extends upsection into the lower Marcellus in southern Indiana, while *I. symmetricus* occurs in the Lingle and Alto Formations in southern Illinois, and *P. pennata* occurs in the Alto Formation in southern Illinois (Klapper et al. 1971, Orr 1964, see Fig. 3).

EIFELIAN		GIVETIAN (PART)				STAGE
ONONDAGA LIMESTONE	HAMILTON GROUP				TULLY FORMATION	NEW YORK Rock Unit
	MARCELLUS FORMATION	SKANATELES FORMATION	LUDLOWVILLE FORMATION	MOSCOW FORMATION		
<u>Icriodus latericrescens n.subsp.A</u>						
JEFFERSONVILLE LIMESTONE	NORTH VERNON LIMESTONE			BEECHWOOD MEMBER		SOUTHERN Rock Unit
	SPEED and MEMBERS	SILVER CREEK				
<u>Icriodus latericrescens n.subsp.A</u>						INDIANA Conodont Ranges
<u>Icriodus angustus</u>						
GRAND TOWER LIMESTONE	LINGLE LIMESTONE	ALTO FM.			SOUTHERN Rock Unit	
<u>Icriodus latericrescens n.subsp.A</u>						ILLINOIS Conodont Ranges
<u>Icriodus angustus</u>						
<u>Icriodus symmetricus</u>						
<u>Polygnathus pennata</u>						
GRAND TOWER LIMESTONE	BEAUVAIS SANDSTONE	St. LAURENT LIMESTONE				SOUTHEASTERN Rock Unit
<u>Icriodus latericrescens n.subsp.A</u>						MISSOURI Conodont Ranges
<u>Icriodus angustus</u>						
<u>Icriodus symmetricus</u>						
<u>Polygnathus pennata</u>						

Fig. 3. Conodont ranges.

Conclusions

Overall, the conodonts indicate a late Eifelian age for the lower 30 feet of the St. Laurent Limestone in the Belgique section. This is about the same age as was indicated by the megafauna. However, the megafossil utilized for dating, *H. aff. coalita*, was found in float blocks, whereas the conodonts were found in situ. The upper 45 feet of the St. Laurent in the Belgique section would range from early to middle Givetian, and perhaps into late Givetian age. Lithologically, in the Belgique section, the St. Laurent appears to grade into Grand Tower Limestone towards the south; however, the conodonts indicate that the southern end of this St. Laurent exposure is the top of the exposed section.

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History of Missouri Junior Academy of Science 1957-1984

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Foreword

The Missouri Junior Academy of Science (now Junior Division of the Missouri Academy of Science) is 18 years old this year. Like the young people it was developed to serve, it has passed through adolescence, teen-age crisis and early adulthood. It now stands strong and firm with a bright future and an increasingly important role in our state.

In 1983 the National Commission on Excellence in Education released their report "A Nation at Risk: The Imperative for Education Reform." This distinguished committee defined "excellence" to mean several related things. "At the level of the *individual learner*, it means performing on the boundary of individual ability in ways that test and push back personal limits, in school and in the work place. Excellence characterizes a *school or college* that sets high expectations and goals for all learners, then tries in every way possible to help students reach them. Excellence characterizes a *society* that has adopted these policies, for it will then be prepared through the education and skills of its people to respond to the challenges of a rapidly changing world. Our Nation's people and its schools and colleges must be committed to achieving excellence in all these senses."

It is interesting to note this same quest for excellence was the driving force to launch a junior academy many years before a national commission was appointed. A quest for excellence in the 1960's at a time when education was "at a low" resulted in many of our present day problems.

The Junior Division of the Missouri Academy of Science is composed of people dedicated to excellence in science and mathematics education. Its strengths are junior high school and high school teachers, industry representatives and educators from our state colleges and universities. Beginning with the initial state meeting held in Kansas City in 1968, a total of 621 research papers have competed for honors and awards. The 16 state meetings have been held on campuses of 15 of our state's public, private and parochial institutions of higher education.

We are indebted to Clayton H. Johnson for telling this story and for reminding us why the Junior Academy is here and why we need to continue in our efforts.

June 1984

Henry A. Mitchell

Associate Vice Chancellor for Academic Affairs

University of Missouri-Kansas City

First State Director - Junior Division of the Missouri Academy of Science

Introduction

The Missouri Junior Academy of Science is still a young institution, having been born in 1967 after a 10-year gestation period. Almost continuous change in the philosophy and personnel of administration has been the norm. However, the goals and objectives and the manner of attaining them have remained almost unchanged, a tribute to the organizational skills of the founders.

The well-known adage that history repeats itself is certainly exemplified in the repetitious character of this history. Because of repetition, errors of omission, especially, may occur. As author, I take full responsibility for these as well as for errors of commission.

Some names of teachers who sponsored and directed student research are not listed because that information was not readily available; for these omissions I apologize. I have tried to be careful with spelling of persons' names; I also apologize for errors which I may have made in these spellings. Titles of persons have changed during the 18 years of this history. I used the title at the time of involvement in part of this history. One person, therefore, might be referred to by different titles as the history progresses.

Acknowledgments

I could not have compiled and written the history without the help of many people who contributed information, encouragement and/or coercion. I take this opportunity to thank the many contributors to my file of information. I cannot name everyone, but the following persons deserve my special expression of appreciation: Gaynell

Symonds, former Managing Editor, MAS; Barbara Chalko, former Business Manager, MAS; Sr. M. Berchmans Bernadt, Bishop LeBlond High School, St. Joseph; Mrs. Marjorie J. Westmoreland, Palmyra High School, Palmyra; and all who served as State Director of MJAS. These persons are Dr. Henry Mitchell, Associate Vice Chancellor for Academic Affairs, University of Missouri-Kansas City; Dr. Richard Myers, formerly Professor of Biology, University of Missouri-Kansas City; Dr. Gary Nahrstedt, School of Education, University of Missouri-Kansas City; Dr. Charles Granger, Department of Biology, University of Missouri-St. Louis; Verlin Abbott, Science Coordinator, Parkway School District, St. Louis; and Dr. Adell Thompson, Department of Biology, University of Missouri-Kansas City. Dr. Kenneth Minter, Department of Biology, Northwest Missouri State University, Maryville, and Director of the Northwest District also was extremely helpful.

Dr. Eva Kirkpatrick provided all the 1984 information.

The First Decade: 1957-1966

In the decade 1957-1966, 2 groups of people independently became interested in initiating in Missouri a program that would enable and encourage secondary school students to perform and to present, publicly, original and independent research in science and mathematics. The earlier, and perhaps more aggressive of these groups, consisted of secondary school teachers in the Kansas City, Mo., area. Some of these teachers and their students had participated in the highly successful program of the Junior Academy of Science in Kansas. This emphasized independent research in science and mathematics by high school students. The goal of these Missouri teachers was to provide this program for all secondary school teachers and students of science and mathematics throughout Missouri.

The other group of persons interested in a program of research for secondary school students was college and university teachers of science and mathematics; these were participants in the National Science Foundation (NSF)-funded program of Visiting Scientists to secondary schools in Missouri. This program prevailed from 1961 through 1965. Visitors to secondary schools reported the interest in research shown by many high school students through their science fair projects. At the same time, the Visitors expressed concern that there was no forum where high school students could present papers describing their research.

In the spring of 1963 the Missouri Academy of Science, which had been inactive for 20 years, was reactivated. This resulted from efforts of persons who participated in the Visiting Scientists Program. Some of these had been instrumental in keeping the College Section of the Academy alive during that 20-year dormant period. The Senior Academy supplied a potential sponsoring organization for a junior academy.

Science teachers in the Kansas City area, who had nurtured random plans for a junior academy in Missouri for many years, finally began to organize those plans in 1964. During 1964, 1965 and 1966 Mr. Donald Shaner, then Chairman of the science department of Park Hill Junior High School, Kansas City, led the drive to elicit support for a junior academy. Support was sought from local teachers, representatives from local and state organizations and secondary school, college and university teachers and administrators throughout the state. Dr. Henry A. Mitchell, Associate Provost for Health Sciences, University of Missouri-Kansas City, worked closely with Mr. Shaner during the early stages of planning.

A meeting of state-wide representatives for the purpose of organizing the Missouri Junior Academy of Science was held in Columbia on April 16, 1966. Dr. Alfred Novak, Chairman, Department of Science and Mathematics, Stephens College, hosted the group which met in the Woods Quadrangle Charter Lecture Room on the Stephens College campus. Representatives were present from public, private and parochial schools; colleges and universities; the Missouri Academy of Science; the Missouri State Department of Education; and Science Teachers of Missouri. A tentative structure of the Junior Academy and guidelines for Academy meetings were discussed. Two high school students presented oral reports of their research projects, using a format proposed for future Junior Academy meetings. A Missouri college student, who had participated in the Junior Academy of Kansas, discussed the influence of that junior academy on her career.

The results of this April 1966 meeting emphasized the need in Missouri to challenge high school students to participate in individual scientific research and to present their research papers orally to their peers and to senior scientists. A junior academy of science was chosen as the vehicle by which this challenge could be made and met. The participants of the Columbia meeting voted unanimously to continue work to establish the Missouri Junior Academy of Science (MJAS).

Requirement for membership in the MJAS was active participation in conducting, supervising or sponsoring investigation leading to the presentation of a paper at a district meeting. Thus, all secondary school students (grades 7-12) and their teachers could become MJAS members without additional formal qualifications or payment of dues. Presentation of original research work to peers and judges at 1 of the 7 MJAS District meetings remains the only means for students to obtain membership in the Junior Academy.

One MJAS Committee was formed. This Committee consisted of state-wide representatives and interested individuals in each of 7 designated districts of the state (Fig. 1). The latter guided activities of the MJAS in their respective districts.

Members of the original Committee and their positions were:

District I (Southwest)

- Dr. A.C. Brewer—Science Coordinator, Springfield Public Schools
- Mr. Art Elbert—Science Instructor, Springfield High School
- Mr. Gary Hall—President, Southwest Missouri Science Teachers Association, Springfield
- Mr. Freddie Mailes—Youth Agent, University of Missouri Extension Center, Carthage

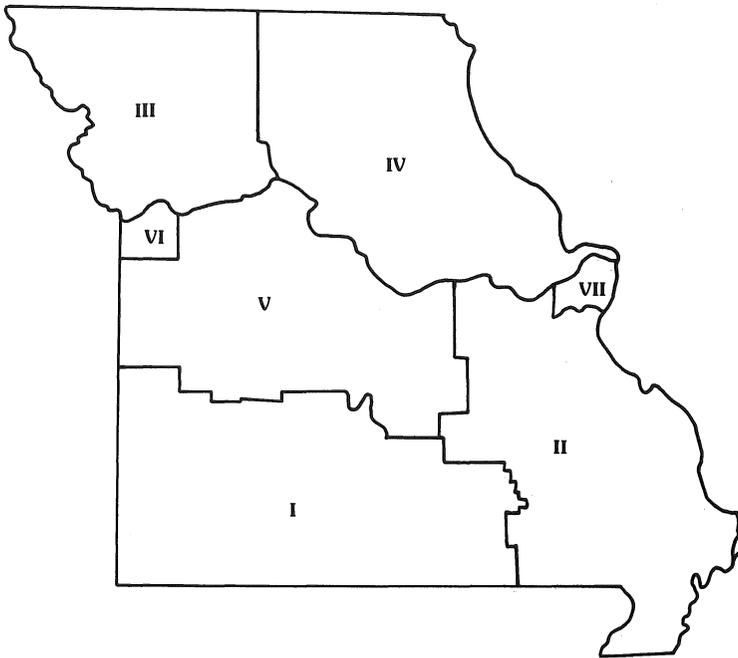


Fig. 1. Proposed districts for the Missouri Junior Academy of Science.

District II (Southeast)

Mr. Leonard Peerman—Agriculture Instructor, Jackson High School
 Mr. Ed Sebaugh—Science Instructor, Jackson High School
 Dr. Donald D. Jewel—Department of Biology, Southeast Missouri State College, Cape Girardeau

District III (Northwest)

Dr. Kenneth Minter—Department of Biology, Northwest Missouri State College, Maryville
 Sister Mary Benet Obear—Science Instructor, Bishop LeBlond High School, St. Joseph
 Sister Seraphine, O.S.B.—Science Instructor, Bishop LeBlond High School, St. Joseph
 Mr. Robert Patience—Science Instructor, R-4 High School, Gilman City

District IV (Northeast)

Dr. D.E. Evans—President, Missouri Science Teachers Association, Kirksville
 Mr. Loren Cross—Physics Instructor, Kirksville High School
 Mr. Walter Clark—Science Instructor, Hannibal Junior High School

District V (Central)

Dr. Richard Myers—Department of Biology, Central Missouri State College, Warrensburg
 Mr. Charles C. Campbell—Assistant Superintendent, Columbia Public Schools
 Dr. Joseph M. Wood—Department of Botany, University of Missouri-Columbia
 Mr. Clarence Hyde—Science Instructor, Clinton High School
 Dr. William Brooks—Department of Science, Lincoln University, Jefferson City
 Mr. Jim Breshears—Science Instructor, West Junior High School, Columbia
 Mr. Donald Shaner—Youth Agent, University of Missouri Extension, Lafayette County, Committee Chairman

District VI (Kansas City)

Mr. Verlin M. Abbott—Science Instructor, Park Hill High School, Kansas City
 Mrs. Marjorie Elliott—Science Instructor, Southwest High School, Kansas City
 Dr. Henry A. Mitchell—Coordinator of Graduate Studies, University of Missouri-Kansas City
 Dr. Gary Nahrstedt—Science Education, University of Missouri-Kansas City
 Mr. Owen Troxell—Science Instructor, Raytown High School
 Mr. Larry Hudson—Science Instructor, Lee's Summit Junior High School

District VII (St. Louis)

- Mr. Louis Lunte—Science Instructor, Lindbergh High School, St. Louis
 Mr. Chester Boston—Science Instructor, Fox High School, Arnold
 Mr. Elmer Headlee—Science Instructor, Kirkwood High School
 Mr. Louis Kassing—Science Instructor, Lindbergh Junior High School, St. Louis
 Mr. Louis Bixby—Science Instructor, St. Louis County Day School
 Mrs. Joanna Brawley—Science Instructor, Ferguson-Florissant High School, Florissant

State-wide representatives

- Mr. John Hoosier—Science Consultant, Missouri State Department of Education, Jefferson City
 Dr. Clayton Johnson—Department of Geology, University of Missouri-Columbia
 Mr. Nelson Trickey—Extension Youth Specialist, University of Missouri Extension Division

Although the MJAS Committee had been formed to guide activities of the Academy, a State Director and an Advisory Board were considered to be essential to unite the activities. November 4 and 5, 1966, Dr. Henry A. Mitchell was appointed as the first State Director, and the Advisory Board was formed. At a meeting of the MJAS Committee in Kansas City, authority was given to the Advisory Board to appoint District Chairmen and to establish policy for and to guide the operation of the MJAS.

Members of the original Advisory Board and their positions were:

- Mr. John Hoosier, Chairman—Science Consultant, Missouri State Department of Education, Jefferson City
 Dr. Clayton Johnson—Department of Geology, University of Missouri-Columbia and Director of the Missouri Academy of Science Visiting Scientist Program
 Mr. Nelson Trickey—Extension Youth Specialist, University of Missouri Extension Division
 Mr. Gary Hall—Science Instructor, Springfield Public Schools and President-elect Missouri Science Teachers Association (Dist. 1)
 Dr. A.C. Brewer—Science Coordinator, Springfield Public Schools (Dist. 1)
 Mr. Ed Sebaugh—Science Instructor, Jackson High School and Secretary of the Southeast Missouri Science Teachers Association (Dist. 2)
 Dr. Kenneth Minter—Department of Biology, Northwest Missouri State College, Maryville (Dist. 3)
 Mr. Loren Cross—Physics Instructor, Kirksville High School (Dist. 4)
 Mr. Donald Shaner—Youth Agent, University of Missouri Extension, Lafayette County (Dist. 5)
 Dr. Francis V. Morris—Midwest Research Institute, Kansas City, Missouri, and President-elect, Missouri Academy of Science (Dist. 6)
 Mr. Louis Lunte—Science Instructor, Lindbergh High School, St. Louis; Chairman, Executive Board, Greater St. Louis Biology Teachers Association and Director, St. Louis Post-Dispatch Science Fair (Dist. 7)

At the November 1966 meeting in Kansas City, the MJAS Committee also received endorsements from Science Teachers of Missouri and the Missouri Academy of Science, both of which pledged to cooperate with and to sponsor the Junior Academy. Further, the MJAS Committee pledged \$200 to defray expenses for past correspondence and for preparing a proposal to the National Science Foundation for financial support for the first year of MJAS activities.

The Second Decade: 1967-1976

Early in 1967 Dr. Henry Mitchell, with enthusiastic aid from Mr. Donald Shaner, Mr. Verlin Abbott, Mrs. Marjorie Elliott and Dr. Richard Myers, wrote the first proposal to NSF. Clayton H. Johnson conferred closely with Donald Shaner about the proposal and edited parts of Shaner's contributions. One week following submission of the proposal, Dr. Mitchell was informed by telephone that NSF awarded \$4541 to MJAS.

An organized MJAS began the 1967-68 academic year with a State Director; guidance of a strong statewide committee; sponsorship and support of 2 state organizations, Science Teachers of Missouri and Missouri Academy of Science; financial support from NSF; and appointed co-directors for each of the 7 districts except District VII for which 1 director was appointed.

The first District Co-directors were:

District I (Southwest)

- Mr. Art Elbert, Glendale High School, Springfield
 Dr. Steve E. Davidson, Evangel College, Springfield

District II (Southeast)

- Mr. Ed Sebaugh, Reorganized School District R-2, Jackson
 Dr. Donald D. Jewel, Southeast Missouri State College, Cape Girardeau

District III (Northeast)

- Sister Mary Benet Obear, Bishop LeBlond High School, St. Joseph
 Dr. Kenneth W. Minter, Northwest Missouri State College, Maryville

District IV (Northeast)

Mr. Loren Cross, Kirksville High School, Kirksville
 Dr. Denman C. Evans, Northeast Missouri State College, Kirksville

District V (Central, including Boone and Howard counties)

Mr. James Breshears, West Junior High School, Columbia
 Dr. William Brooks, Lincoln University, Jefferson City

District VI (Kansas City, Jackson, Clay and Platte counties)

Mr. Donald Shaner, Excelsior Springs High School, Excelsior Springs
 Dr. Gary Nahrstedt, University of Missouri-Kansas City

District VII (St. Louis - St. Louis, St. Charles and Jefferson counties)

Mr. Verlin M. Abbott, Parkway School District, Woods Mill and Ladue Road, Chesterfield

The 1967-68 academic year for MJAS culminated in March with a meeting held in each of the 7 Districts under guidance of the respective District Directors. One hundred forty-seven students presented papers on their individual research. The authors and presentors of the 40 papers considered as the most outstanding, and their teacher-sponsors, were invited to attend the first state meeting of MJAS and to present their papers on April 27, 1968, at the University of Missouri-Kansas City. This meeting was held jointly with the annual state meeting of Missouri Academy of Science and the spring meeting of Science Teachers of Missouri. The papers were presented in separate concurrent sections, including Botany, Chemistry, General Biology, Physical Science I, Physical Science II and Zoology. Students were given special certificates and ribbons for their presentations. The student presenting the most meritorious paper in each section received a special plaque which was donated by the Science Teachers of Missouri. The plaques were to be displayed in the students' high schools for 1 year.

In this first state meeting of MJAS, the winner in each section, the title of the paper, and the sponsoring teacher were:

Botany (6 papers)

Ann Happel, Palmyra High School, Palmyra; "Properties in Corn"; Marjorie Westmoreland, sponsoring teacher.

Chemistry (7 papers)

Michael Schwartz, Parkway Central High School, Chesterfield; "The Favoring of Types of Organic Compounds Formed Under Varied Primeval Conditions"; Melba James, sponsoring teacher.

General Biology (6 papers)

Patti Kester and Martha Loos, Central High School, Cape Girardeau; "ESP-Fact or Fantasy?"; John D. Rigdon, sponsoring teacher.

Physical Science I (7 papers)

Patrick Fagan, Palmyra High School, Palmyra; "Slide Rule for Complex Numbers"; Marjorie Westmoreland, sponsoring teacher.

Physical Science II (8 papers)

Ted Barnes, Park Hill High School, Kansas City; "Control of Deviations in Electromagnetic Plasma Pinch through the Injection of Transverse Magnetic Fields"; Robert Solomon, sponsoring teacher.

Zoology (6 papers)

William Ziegler, Park Hill High School, Kansas City; "The role of Macrophages in Cholesterol Production and Atherosclerosis"; Robert Solomon, sponsoring teacher.

In May 1968 MJAS received continued funding of \$4546 from NSF. Dr. Mitchell requested to be relieved of the state directorship, but agreed to a 1-year appointment as Co-director with Dr. Gary Nahrstedt, School of Education, University of Missouri-Kansas City.

Several other changes were made by and in the MJAS Committee and the Advisory Board. The St. Louis District (VII) was altered to include St. Charles, St. Louis and Jefferson counties. The Kansas City District (VI) was changed to include Platte, Clay and Jackson counties. Boone and Howard counties were extracted from the Northeastern District (IV) and added to the Central District (V) (Fig. 2).

Mr. Howard Westerman, Belton High School, and Dr. Eugene Oshima, Central Missouri State College, were appointed Co-directors of District V to replace Mr. James Breshears and Dr. William Brooks, respectively. Dr. Richard Myers, University of Missouri-Kansas City, was appointed to replace Dr. Gary Nahrstedt as Co-director in District VI; and Mr. Kenneth V. Fast, Kirkwood High School, was appointed Co-director in District VII. Dr. Kenneth G. Brill, Jr., Department of Geology, St. Louis University, replaced Dr. Francis V. Morris on the Advisory Board. Three new sections—Earth Science, Mathematics, and Social Science—were added to the original five.

At the 1968 annual state meeting of MJAS in Kansas City, Dr. Gary Nahrstedt became the sole State Director of the Junior Academy.

During the 1968-69 academic year, 231 students, an increase of 84 from the previous (initial) year, presented results of their individual research at the 7 district meetings. Although this was a 57% increase in the number of papers presented at the district meetings and 3 new sections had been added, only 40 papers were selected to be presented at the annual state meeting at St. Louis University on May 3, 1969. As had been done previously, the presenter of the most highly rated paper in each section received a plaque awarded by Science Teachers of Missouri.

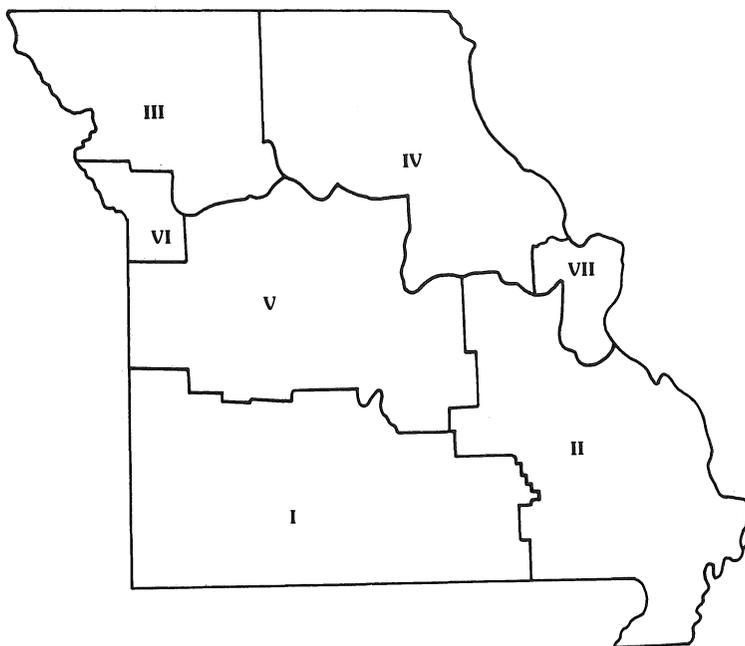


Fig. 2. Revised districts for the Missouri Junior Academy of Science.

The number of papers, the name of the presenter of the outstanding paper, and the title of the paper in each section follow. Social Science papers were presented for the first time in 1969.

Botany (4 papers)

Ann Happel, Palmyra High School, Palmyra; "A Study of the Waxy Characteristics in Corn Having a Waxy Endosperm"; Ruth Kespohl and Marjorie Westmoreland, sponsoring teachers.

Chemistry (5 papers)

John Schier, St. Louis Priory School, St. Louis; "Catalytic Decomposition of Sodium Hypochlorite by the Oxides of Cobalt, Nickel, and Iron"; Father Thomas Loughlin, sponsoring teacher.

Earth Sciences (3 papers)

David K. Aubuchon, Jackson Jr. High School, Jackson; "Lunar Photography"; Mrs. Alfred Kester, sponsoring teacher.

General Biology (6 papers)

James D. Wheeler, William Chrisman High School, Independence; "The Effects of Caffeine on Cholesterol Biosynthesis"; Oneida Beeman, sponsoring teacher.

Mathematics (4 papers)

Jeanne Marr, Bishop LeBlond High School, St. Joseph; "Programming the IBM 1130 Computer for the Solution of a Quadratic Equation"; Sister Mary Benet and Brother Edwin Scherry, sponsoring teachers.

Physical Science (6 papers)

Raymond Clore, Pittman Hills Jr. High School, Kansas City; "The Nucleus: The Structure and Reactions Therein"; J.C. Hassall, sponsoring teacher.

Social Sciences (6 papers)

Gary E. Brown, Lafayette High School, Ellisville; "The Effects of the Number of Environmental Companions on Selective Learning in Male White Rats"; David L. Hopkins, sponsoring teacher.

Zoology (6 papers)

Bradford P. Keeney, Smithville High School, Smithville; "An Experimental Study of the Effect of Adrenalin on the Glycogen Content of Hepatic Tissues Perfused in Vitro"; Robert Sandpot, sponsoring teacher.

The 1969-70 year for MJAS began rather bleakly due to a precarious financial foundation, a dismal fiscal outlook and the near lack of guidance from a dilatory Advisory Board. Under the aggressive leadership of State Director Dr. Gary Nahrstedt, however, the management and operation of MJAS were strengthened. In spite of the fact that NSF had alerted MJAS that financial support would likely be less than 50% of that for the previous year, Dr. Nahrstedt submitted a proposal. MJAS agonized throughout the summer and fall semester without funds. Planning for activities became difficult to nearly impossible. Finally, in February 1970 NSF approved a \$1977 grant. Although this was less than half of the original request, it was sufficient to permit the necessary activities of the district and state meetings, the latter of which was to be held at Central Missouri State College, Warrensburg, on April 24-25, 1970.

During the summer of 1969, the Advisory Board changed the basis for selection of its membership. A new Board would consist of 13 members, including a representative from each of the 7 districts, 1 representative appointed by the president of Science Teachers of Missouri, 1 appointed by the president of Missouri Academy of Science, 1 from the Cooperative Extension Service, 1 from the State Department of Education, the State Director of MJAS and a past State Director of MJAS. Members of the Advisory Board were to elect a chairman from their membership exclusive of the State Director of MJAS, who was declared ineligible. Clayton H. Johnson was elected as the first chairman of the Board.

Membership of the revised Advisory Board for 1960-70 was:

Dr. Clayton H. Johnson, Chairman, University of Missouri-Columbia
 Mr. Ernest A. Dunning, Kirkwood, Missouri Public Schools
 Dr. Denman C. Evans, Northeast Missouri State College
 Mr. John Hooser, Missouri State Department of Education
 Mr. Larry Hudson, Lee's Summit, Missouri Public Schools
 Dr. Dan Millikan, University of Missouri-Columbia
 Dr. Henry A. Mitchell, University of Missouri-Kansas City
 Dr. Gary W. Nahrstedt, University of Missouri-Kansas City
 Mr. Don Shaner, University of Missouri Extension
 Mr. Nelson Trickey, University of Missouri Cooperative, Extension Service-Columbia
 Dr. Kenneth Brill, St. Louis University

The conditions for term of office were not specified for the district directors or Advisory Board members except that those Board members who represented Science Teachers of Missouri, the Missouri Academy of Science, the Cooperative Extension Service and the State Department of Education could be replaced only by action of the respective organization represented.

Responsibilities and duties of the Advisory Board were redefined as: 1) to meet at least once a year, although the chairman could call other meetings as needed; 2) to select the State Director; 3) to select 2 co-directors for and an Advisory Board member from each district from names submitted by interested and appropriate persons or organizations such as Science Teachers of Missouri, the Missouri Academy of Science, and MJAS teacher sponsors; 4) to evaluate MJAS procedures and promote effective working policies for the organization; and 5) to publicize and solicit funds to support the mission and activities of MJAS.

Changes from 1968-69 were made in the co-directorship of 3 districts. Mr. Ken Ornes, Center North Junior High School, Kansas City, replaced Don Shaner as Director of District VI. Mrs. Marjorie Westmoreland, Palmyra R-I High School, Palmyra, and Dr. John Settlege, Northeast Missouri State College, Kirksville, respectively, replaced Loren Cross and Denman Evans in District VI. Mr. Robert E. Thurman replaced Steve Davidson after the latter's resignation in District I.

The 1969-70 roster of District Directors follows:

District I (Southwest)

Mr. Art Elbert, Glendale High School, Springfield
 Mr. Robert E. Thurman, Southwest Missouri State College, Springfield

District II (Southeast)

Mr. Ed Sebaugh, Reorg. School Dist. R-2, Jackson
 Dr. Donald Jewel, Southeast Mo. State College, Cape Girardeau

District III (Northwest)

Sister Mary Benet Obear, Bishop LeBlond High School, St. Joseph
 Dr. Kenneth W. Minter, Northwest Missouri State College, Maryville

District IV (Northeast)

Mrs. Marjorie Westmoreland, Palmyra Dist. R-1, Palmyra
 Dr. John Settlege, Northeast Missouri State College, Kirksville

District V (Central)

Mr. Howard Westerman, Belton High School, Belton
 Dr. Eugene Oshima, Central Missouri State College, Warrensburg

District VI (Kansas City)

Mr. Ken Ornes, Center North Junior High School, Kansas City
 Dr. Richard Myers, University of Missouri-Kansas City

District VII (St. Louis)

Mr. Verlin Abbott, Parkway School District, Chesterfield
 Mr. Kenneth Fast, Kirkwood School District, St. Louis

A bronze medal award named for Mr. Wayne Troxell was established in 1970 by his widow from contributions from friends, teachers and members of MJAS. The medal is for first and second place winners in the District VI MJAS competition. Mr. Troxell, a devoted science teacher and a founder of MJAS, taught biology and physiology at Raytown High School, Raytown, from 1961 until his death in July 1969. Nine students received the medal for their presentations in March 1970. Five of these winners also presented their papers at the MJAS State Meeting at Central Missouri State College in Warrensburg in April 1970.

Thirty-six papers were presented in 7 sections in this third annual, 1970, meeting. Names of the presentors of outstanding papers, the titles, and names of sponsoring teachers follow:

Botany (6 papers)

Christy Klein, Parkway Central Jr. High School, Chesterfield; "Inquiry - The Effect of Stimulus/Time of Day Applied Relationship"; Keith A. Vemmer, sponsoring teacher.

Chemistry (3 papers)

John J. Schier, St. Louis Priory School, St. Louis; "The Mechanism of the Catalytic Action of Cobalt Oxide on the Decomposition of Hypochlorite"; W.T. Loughlin, sponsor teacher.

Earth Science (3 papers)

Stephen Alan Miceli, Horton Watkins High School, Ladue; "Study of Solar Astronomy and Sunspot Analysis"; Marvin Friedley, sponsoring teacher.

General Biology (7 papers)

Candace Henneberry, South Shelby High School, Shelbina; "A Study of the Effects of Synthetic Detergents on Goldfish"; Howard Platz, sponsoring teacher.

Barbara Sears, University High School, Columbia; "The Indirect Effects of Pollution on *Campostoma anomalum*"; Michael Easter, sponsoring teacher.

Physical Science and Mathematics (5 papers)

Victor J. Vouga, Horton Watkins High School, Ladue; "Aerodynamics"; Marvin Friedley, sponsoring teacher.

Social Science (5 papers)

James S. Moran, St. Louis Priory School, St. Louis; "Visual Perception in the Pigeon"; W.T. Loughlin, sponsoring teacher.

Zoology (7 papers):

Debbie K. Watring, Otterville High School, Otterville; "Radiation Affecting Sex-Ratio in *Drosophila*"; Rheta J. Smith, sponsoring teacher.

Clayton Johnson asked to be relieved as chairman and member on the Advisory Board. This request was granted and new board members were elected to begin terms in April 1970. John Hooser, Nelson Trickey and Don Shaner were retained on the Advisory Board; the persons listed below were elected to first terms. Don Shaner was elected to the chairmanship and Gary Nahrstedt continued as State Director.

Mr. Ernest A. Dunning, Public Schools, Kirkwood

Mr. Art Elbert, Public Schools, Springfield

Dr. Denman C. Evans, Northeast Missouri State College

Mr. Larry Hudson, Public Schools, Lee's Summit

Dr. Dan Millikan, University of Missouri-Columbia

Dr. Henry A. Mitchell, University of Missouri-Kansas City

Dr. Gary Nahrstedt, University of Missouri-Kansas City

Newly appointed District Co-directors were Mr. Joe Tuck, Bolivar Public Schools, and Dr. Bruno Schmidt, Southwest Missouri State College, in District I; and Sister Maxine Zeller, Bishop LeBlond High School, St. Joseph, in District III.

The fourth Annual State Meeting of MJAS was held on the campus of Drury College, Springfield, on April 24, 1971. Thirty-four papers were presented in 8 sections. Increasing maturity of the Academy was indicated by at least 3 persons repeating as presentors. Each of these presented results of the third year of continued investigation of his original research subject. Winners, their papers and their sponsoring teachers were:

Botany (5 papers)

Michael A. Harter, Raytown South High School, Raytown; "Determination of Minimum Acceleration Necessary to Cause Geothropic Reaction in Corn Seedlings"; Terry Williams, sponsoring teacher.

Chemistry (2 papers)

Robert Charnas, Horton Watkins High School, Ladue; "A Wet Chemical Analysis of the Chemical Species in Drinking Water"; Marvin Friedley, Henry Becker, and Jack Young, sponsoring teachers.

Earth Science (3 papers)

David Aubuchon, Jackson R-I High School, Jackson; "Astro-Photography with Ammoniated Film"; Ed Sebaugh, sponsoring teacher.

General Biology (4 papers)

Joanie Insko, LeBlond High School, St. Joseph; "Testing the Biodegradability of Detergents"; Sister Maxine Zeller, sponsoring teacher.

John W. Head, Palmyra R-I High School, Palmyra; "Effects of Sulfur Dioxide on *Blepharisma*"; Marjorie Westmoreland, sponsoring teacher.

Mathematics (3 papers)

Joan Lorraine Snodgrass, Palmyra High School, Palmyra; "Trigonometry on a Non-Euclidian Circle"; Donald Nations, sponsoring teacher.

Physical Science (6 papers)

James L. Sutton, Palmyra R-I High School, Palmyra; "Relating Characteristic Properties"; Donald Nations, sponsoring teacher.

Social Sciences (4 papers)

Gregory A. Love, Glendale High School, Springfield; "Therapeutic Conditioning of the Anxiety Syndrome by Conformation of Theta Percentages"; sponsoring teacher unknown.

Zoology (7 papers)

John Feagan, Nevada High School, Nevada; "Amino Acid Absorption in *Rana pipiens* Embryos"; L.C. Haller, sponsoring teacher.

Dr. Gary Nahrstedt resigned the state directorship in 1970, and Dr. Richard Myers, Department of Biology, University of Missouri-Kansas City, became the State Director.

The 1972 meeting was held on April 29 at Southeast Missouri State College in Cape Girardeau. Papers by 29 high school students were presented in 8 sections. Four presentors were repeaters from the previous year. Two of these presented the results of research in a different field from that of the preceding year, whereas 2 others had continued their earlier investigations. One of these presented at least his third paper at a state meeting of MJAS.

The winners of the Science Teachers of Missouri plaques, titles of their papers and their sponsoring teachers are given below:

Botany (2 papers)

Rodman Kirkpatrick, Fox Senior High School, Arnold; "Effects of Magnetism on Plant Growth"; C. Boston, sponsoring teacher.

Chemistry (2 papers)

Gary Cupples, Horton Watkins High School, Ladue; "The Effects of Altering the State of Ionization of Polymeric Acids"; H. Becker and Chester F. Nuller, sponsoring teachers.

Earth Science (3 papers)

Michael Fuller, Glendale High School, Springfield; "A Preliminary Archeological Report on the Chemical Analysis and Correlation of Data from Two Sites in Central Oregon"; M.P. Fuller, sponsoring teacher.

Mathematics (3 papers)

Lounell Snodgrass, Palmyra High School, Palmyra; "Mathematical Analysis of Group Structures in Our Society"; Ruth Kespohl, sponsoring teacher.

General Biology (5 papers)

Jerry Smith, Liberal High School, Liberal; "Nitrates and Ecology"; Hugh Nicolas, sponsoring teacher.

Physical Science (5 papers)

Walter Meister, Purdy High School, Purdy; "An Investigation of Internal Electrical Modulation of a Flame (The Sound of Music out of a Flame)"; Hozium Nuayem, sponsoring teacher.

Mark Barteau, St. Louis Priory School, Creve Coeur; "An Investigation of Slow Particles: Their Nature and Origin"; W.T. Loughlin, sponsoring teacher.

Social Science - Psychology (2 papers)

Burt Levitch, Horton Watkins High School, Ladue; "Establishing Effective Predictors of School Achievement"; Chester F. Nuller and H. Becker, sponsoring teachers.

Zoology (4 papers)

Oscar Schwartz, Parkway Central High School, Chesterfield; "Effects of Propylthiouracil on the Rat"; Jean Lemmons, sponsoring teacher.

Between 1970 and 1973, several District Directorships were changed. Ernest Ferguson and William Thomas replaced Joe Tuck and Bruno Schmidt in District I. Sister M. Berchmans Bernadt, LeBlond High School, St. Joseph; Gerald Zweerink, Central High School, St. Joseph; and Harry Force, Western Missouri College, St. Joseph, replaced Sister Maxine Zeller and Kenneth Minter in District III. Howard Platz, South Shelby High School, Shelbina, replaced Marjorie Westmoreland in District IV. Jim Hall and Adell Thompson, University of Missouri-Kansas City, replaced Ken Ornes and Richard Myers in District VI. James Hoerter replaced Howard Wedeman in District V; and Eva Kirkpatrick replaced Kenneth Fast in District VII.

The American Association for the Advancement of Science, through auspices of the Missouri Academy of Science, became a source of financial support for activities of the MJAS in 1973. Support went to individual students in the form of grants for a maximum of \$50 "for the encouragement of research among high school students." The money was to be used for purchase of expendable laboratory materials necessary for the student's research. Students had to formally apply for grants in competition with others; the money could be used for summer or school term research.

Initial awards from AAAS-MAS were \$25 each to Katherine Burton, chemistry, and Britt Thedinger, biology, both of Bishop LeBlond High School, St. Joseph. Sister Mary Berchmans Bernadt sponsored their applications.

Early in 1973, Richard Myers, State Director, began a new job and found it impossible to attend to needs of MJAS, especially planning of the Annual Meeting. His sudden resignation from the State Directorship necessitated adjustments in the usual format of the Annual Meeting. These adjustments were made by Dr. Charles Granger, Department of Biology, University of Missouri-St. Louis, who accepted the State Directorship 2 weeks before the Annual Meeting held April 28 on the University of Missouri-Columbia campus. Robert Combs, Secretary of MAS and Professor of Electrical Engineering, University of Missouri-Columbia, was able to reserve 2 rooms in the Electrical Engineering Building for MJAS. This permitted 2 concurrent sessions and required combining all the physical sciences and mathematics for 1 session and the biological and social sciences for the other, instead of the usual 7-9 concurrent sessions. A limitation was placed on the number of papers that could be accepted for presentation, but no change was made in the procedure for determining winners of Science Teachers of Missouri plaques in the usual disciplines. Twenty-one participants presented papers; at least 3 of whom were repeaters. One presented for the fourth time and another for the third time, the first 2 having been as junior high school students.

The names of the winners in 1973, and their research subjects, follow:

Botany

Rodman Kirkpatrick, Fox High School, Arnold; "An Investigation into Magnetotropism of *DeKalb XL-45 Graminal zea mays.*"; C. Boston and E. Kirkpatrick, sponsoring teachers.

Chemistry

Kim Ledbetter, Grandview High School, Grandview; "Investigation of Effects of Human Clorionic Gonadotropin on the Estrous Cycle of *Rottus norvegicus* (Mature Rat)."

Social Science

Rusalyn Andrews, Delta High School, Delta; "Statistical Survey of Typing Students."

Continued growth of MJAS and changes in perspective of participating sponsoring teachers and District Directors during the first 6 years of existence of the junior academy necessitated a reexamination of the objectives, goals and procedures of MJAS. Principal suggestions for change were 1) to establish a closer link between MJAS and the senior academy, perhaps by making the former a division of MAS comparable to the College Division; 2) to establish a body of governing officers in MJAS; 3) to establish minimal dues in MJAS; 4) to hold MJAS paper sessions at the Annual Meeting on Friday afternoons as opposed to Saturday mornings in competition with MAS paper sessions; and 5) to adopt a constitution and by-laws or other guidelines. Some of these suggestions required changes in the Constitution of MAS. For example, to make MJAS a division of MAS requires an alteration of both Article 2, Membership, and Article 5, Sections.

Soon after he accepted the State Directorship early in 1973, Dr. Charles Granger planted the seeds for changes in a non-dated memorandum to all District Directors and members of the Advisory Board. Also, prior to December 1973 Dr. Granger conferred with Mr. M. L. Hammer, General Public Relations Manager of Southwestern Bell in St. Louis on possible ways by which Bell Telephone Laboratories "could assist in the effort to stimulate an interest in science and mathematics among the youth of Missouri." A letter, dated December 7, 1973, from Mr. Hammer to Dr. Granger stated, "We do want to make a financial contribution to the Missouri Junior Academy of Science on a statewide basis. The enclosed check for \$500 we hope you will use for projects in all 7 of the operating Academy districts." Furthermore, Mr. Hammer had discussed the MJAS program with Mr. Robert Selleck, his counterpart in Kansas City, from whom half the monetary contribution would come. These men concurred that their company could "lend manpower assistance to Districts VI and VII where Southwestern Bell has a larger group of technically trained employees."

Dr. Granger accepted these offers of financial and manpower support in a letter to Mr. Hammer, dated December 11, 1973. Dr. Granger also requested that a representative of Southwestern Bell serve on the Advisory Board of MJAS. Mr. Allen Clark, Customer Service Engineer, therefore was appointed prior to the 1974 Annual Meeting.

Early in 1974, through the efforts of Dr. Granger for the Junior Academy and Mr. George P. Kuechler of Union Electric Company, St. Louis, that company also proffered financial and manpower support to the Junior Academy. Dr. Gerald E. Dreifke, Research Division Head of Union Electric Company, was appointed as that company's representative on the Advisory Board of MJAS.

The membership of the Advisory Board in 1974 was:

Charles Granger, State Director, University of Missouri-St. Louis
 Art Albert, Kickapoo High School, Springfield
 Theresa Bauman, Southeast High School, Kansas City
 Allen Clark, Southwestern Bell, St. Louis
 Ernest A. Dunning, North Kirkwood Jr. High, Kirkwood

Gerald E. Dreifke, Union Electric Company, St. Louis
 Denman C. Evans, Northeast Missouri St. University, Kirksville
 Larry Hudson, Lee's Summit School District, Lee's Summit
 Daniel F. Millikan, University of Missouri-Columbia
 Henry A. Mitchell, University of Missouri-Kansas City
 Don Shaner, Meridian School District, Mounds, Illinois

The District Co-Directors in 1974 were:

District I (Southwest)

Joe Tuck, Bolivar R-I schools, Bolivar
 Bruno Schmidt, Southwest Missouri State University, Springfield

District II (Southeast)

Ed Sebaugh, Jackson High School, Jackson
 Donald D. Jewel, Southeast Missouri State University, Cape Girardeau.

District III (Northwest)

Sr. M. Berchmans Bernadt, Bishop LeBlond High School, St. Joseph
 Gerald Zweerink, Central High School, St. Joseph
 Harry Force, Western Missouri College, St. Joseph

District IV (Northeast)

Howard Platz, South Shelby High School, Shelbina
 John H. Settlage, Northeast Missouri State University, Kirksville

District V (Central)

Howard Westerman, Belton High School, Belton
 Eugene A Oshima, Central Missouri State University, Warrensburg

District VI (Kansas City)

Oneida Beeman, William Chrisman High School, Independence
 Adell Thompson, University of Missouri-Kansas City

District VII (St. Louis)

Eva Kirkpatrick, Fox C-6-Seckman Jr. High School, Imperial
 Verlin M. Abbott, Parkway School District, Chesterfield

Three new types of recognition related to the activities of MJAS were initiated and awarded for the first time in 1974. One of these awards was to honor outstanding science teachers. Recognition of the educational contributions of high school science teachers would publicize the excellent work being done in many of Missouri's high schools. This award, for innovative and effective teaching techniques and practices, was to be presented annually to 1 teacher in each of the 7 Junior Academy Districts.

In addition to financial and manpower support, Union Electric Company and Southwestern Bell each offered, in 1974, a Sponsor's Trophy to a student. The Union Electric Trophy was for "the best original research on energy," and the Southwestern Bell Trophy was for "exploration in the field of communication science." All student participants in the MJAS Annual State Meeting were eligible to receive these awards.

The 1974 Annual State Meeting of MJAS was held on Friday, April 26, on the campus of Northwest Missouri State University in Maryville. Twenty-two schools were represented, and 26 different teachers had supervised the students research that resulted in 38 papers being presented in 7 sessions. None of the presentors had given a paper at the previous annual meeting. Two papers were co-authored, giving a total of 40 student participants.

The names of winners of the Science Teachers of Missouri plaques for outstanding papers are listed below along with their schools, titles of their papers and names of sponsoring teacher.

General Biology (6 papers)

Steve Hamilton, Jackson High School, Jackson; "Environmental Conditions of Goose Creek"; Michael Harrison, sponsoring teacher.

Microbiology (7 papers):

Rick Borchelt, Campus High School, Cape Girardeau; "The Use of *Entomophthora muscae* to Control *Musca domestica*"; Phil Phillippe, sponsoring teacher.

Zoology (6 papers)

Steven Younger, Hillcrest High School, Springfield; "On Primary Perception in Eggs"; Hugh Brewer, sponsoring teacher.

Chemistry (7 papers):

Anthony S. Shin, Horton Watkins High School, Ladue; "Effect of Types of Polyelectrolytes and their Synergistic Action on the Ability of Inhibiting the Crystallization of CaSO_4 "; Anthony Kardis, sponsoring teacher.

Mathematics (4 papers)

Corwin Wheeler, Lillis High School, Kansas City; "The Odds are Better than Even - A Mathematical Analysis of the Fairness of the Oregon Odd-Even Plan of Gasoline Allocation"; Sister de Montfort, sponsoring teacher.

Physics (5 papers)

Scott Rosenberg, Horton Watkins High School, Ladue; "The Construction and Operation of a Model Mass Spectrograph"; Chester F. Miller, sponsoring teacher.

Social Science (3 papers)

Lisa Redhage and Loretta Rinne, Lafayette Co. C-I High School, Higginsville; "Rorschach Inkblot Test Result Variations by Age and Sex"; Dennis Stewart, sponsoring teacher.

The 1974 awardees of AAAS-MAS grants and their sponsors follow. Each grant was \$25 to support research in biology.

Michael Donaher, LeBlond High School, St. Joseph; Sister M. Bernadt, sponsor.

Marlene Drag, LeBlond High School; Sister M. Bernadt, sponsor.

Jeff Harris, South Shelby High School, Shelbina; Howard Platz, sponsor.

Joseph Stehr, LeBlond High School, Sister M. Bernadt, sponsor.

Following reorganization of MJAS, the individual districts were encouraged to initiate distinctive local programs. The Wayne Troxell bronze medal award was established in 1970 in District VI. In 1974, District I started to award a scholarship to Southwest Missouri State University "to a student giving an outstanding presentation at the District I meeting." Steven Younger, Hillcrest High School, Springfield, won the \$200 scholarship in 1974. He went on to win a Science Teachers of Missouri plaque at the State meeting for his paper entitled "On Primary Perception in Eggs." In 1975, (at the District I meeting), Therese Cashel won the \$240 scholarship for her work on "Effects of Color in Converting Light Energy into Heat Energy." Later, both students attended Southwest Missouri State University.

The care with which members of the Advisory Board and District Directors were chosen in 1973 and 1974 is reflected by the lack of changes in 1975. Consequently, the 2 bodies remain unchanged, as did the State Directorship.

The eighth Annual State Meeting of MJAS was held on the campus of William Jewell College, Liberty, on April 25-26, 1975. Twenty-six schools were represented by 51 students, who had been supervised by 29 teachers in their research. Forty-eight papers were presented in 8 concurrent sessions. Three papers were co-authored, and 3 students were supervised by a pair of teachers. Six students had presented papers in 1974. The names of winners of the Science Teachers of Missouri plaques in the 8 sessions, titles of their papers and names of the sponsoring teachers follow.

Behavioral (Social) Sciences (5 papers)

Barbara Jean Gartner, William Chrisman High School, Independence; "The Effects of Electrical Shock on Territorial Behavior of Male *Betta splendens*"; Oneida Beeman, sponsoring teacher.

Botany (5 papers)

Billy J. Simmons, Central High School, St. Joseph; "The Concentration and Distribution of Arsenic When used as a Herbicide, in the Form of Disodium - methanearsenate, on *Poa pratensis*"; C.W. McLaughlin, sponsoring teacher.

Chemistry (7 papers)

Margaret Raymond, Notre Dame de Sion High School, Kansas City; "An Investigation into the Utilization of Corncobs in Paper Production"; Larry Learning and Clarence Classen, sponsoring teachers.

Environmental Chemistry (5 papers)

David Shapiro, Horton Watkins High School, Ladue; "Thin-Layer Chromatography as a Method for the Analysis of Waste Water Samples for the Presence of Carcinogens"; A. Kardis, sponsoring teacher.

Engineering, Mathematics, and Physics (6 papers)

Albert Lin, Central High School, St. Joseph; "The Study and Comparison of the Effects of Flame Retardant Materials When Applied to Textiles and Polymeric Solids in Uncontrolled Combustion"; C.W. McLaughlin, sponsoring teacher.

Environmental Studies (7 papers)

Bobbie Hatler, Jackson High School, Jackson; "The Effects of Increasing Intensities of Constant and Intermittent Noise on the Metabolic Rate of *Meriones unguiculatus*"; Michael Harrison, sponsoring teacher.

Microbiology (6 papers)

Peggy Sassenrath, John Burroughs High School, St. Louis; "An Analysis of the Relationship between Tumor-Inducing Ability and the Metabolism of the Individual Mutants"; Bruce Westling, sponsoring teacher.

Physiology (7 papers)

Alan Scott Keviatek, Horton Watkins High School, Ladue; "The Effect of Oxalic Acid on the Toxicity of Cinnabar (HgS)"; A. Kardis, sponsoring teacher.

Four secondary school teachers received the first Outstanding Science Teacher Awards from the Missouri Academy of Science at the 1975 Annual Meeting of MJAS. Winners were:

Cyrla Jan Alderson, Pittman Mills Junior High School, Raytown, District VII.

Gordon S. Griffin, Charleston R-I High School, Charleston, District II.
 Fred S. Pitts, Carl Junction R-I Jr. High School, Carl Junction, District I.
 Robert L. Dornfeld, Pattonville Holman Jr. High School, St. Ann, District VII.

Two students, both at Raytown High School, were awarded AAAS-MAS grants in 1975 to support their research. Debby Riggs, who worked in biology, was sponsored by Robert P. Harper; and Loren D. Wallen, who worked in physics, was sponsored by Charles Hibler.

Prior to the 1976 State Annual Meeting, the widow of Dr. John Paul Morris, in memory of her husband, established a \$25 award to be offered annually "to a young woman (secondary school student) who demonstrated an interest and aptitude in physical science." Dr. Morris, Professor of Physics at Central Missouri State University, had been an early member and strong supporter of the Missouri Academy of Science and was President in 1969-70. Throughout his professional career, he had been interested in the encouragement of young women in the sciences. The first Dr. John Paul Morris Award was presented at the ninth Annual Meeting (1976) at Rolla to Marlene Drag, Bishop LeBlond High School, St. Joseph. She was strongly supported by her research supervisor and teacher of chemistry and physics, Sister Mary Berchmans Bernadt. Miss Drag's paper entitled "The Conformity of Rhodopsin Bleaching to the Bunsen-Roscoe Law," was presented in the Chemistry Session of MJAS in Rolla.

In 1975, The American Association for the Advancement of Science (AAAS) awarded Honorary Student Memberships to 2 Missouri Junior Academy nominees. The Award consisted of an Honor Student certificate and a year's subscription to *Science*, the AAAS journal. Fewer than 100 such awards are made annually. The awardees were Peggy Sassenrath, John Burroughs High School, St. Louis; and Albert Lin, Central High School, St. Joseph.

During the 1975-76 academic year, more than 350 secondary school students pursued research programs leading to presentation of papers at the District level. Fifty-six students, representing all 7 districts and 29 schools, presented their research papers in 8 concurrent sessions at the ninth Annual State Meeting on the campus of the University of Missouri-Rolla in April 1976. The research of these students had been supervised by 37 teachers. The names of the winners of the Science Teachers of Missouri plaques for outstanding papers, titles of the papers and their sponsoring teachers follow:

Behavioral (Social) Science (8 papers)

Leonard Alan Sonnenschein, Clayton High School, Clayton; "How Mice Are Affected by Spectral Variation in Artificial Light"; C.T. Lange, sponsoring teacher.

Chemistry (6 papers)

Diane Lynn Medved, Notre Dame de Sion High School, Kansas City; "The Oil Sorption Capacities of the Aromatic Hydrocarbons, Polystyrene Closed Cell Foam, Polystyrene Open Cell Foam, and Polyurethane Flexible Foam"; Clarence Classen and Larry Leaming, sponsoring teachers.

Engineering and Mathematics (7 papers)

Kim Bowyer, Neosho High School, Neosho; "Construction of an Inexpensive Gas Chromatograph"; Ernest Ferguson, sponsoring teacher.

Microbiology (8 papers)

Scott Brundage, Horton Watkins High School, Ladue; "The Oxidation of Oil Shale and Petroleum by *Thiobacillus thiooxidans*"; Anthony Kardis, sponsoring teacher.

Physics (7 papers)

Mike Schmidt, Grandview High School, Grandview; "Concordance and Discordance"; Dale Endicott, sponsoring teacher.

General Biology (7 papers)

Vernon L. Kasten, Jackson High School, Jackson; "A Study of Various Concentrations of Glucose on Embryonic Chick Heart Development"; Michael Harrison, sponsoring teacher.

Genetics (7 papers)

Mitch Phillips, Highland High School, Ewing; "A Study Concerning Genetic Analysis and the Effect of Various Antioxidants and Membrane Stabilizers on the Tumor and Life Span of a *Drosophila melanogaster* Mutant"; Rod Higgins, sponsoring teacher.

Physiology (5 papers)

Gregory T. Wirt, Parkway North High School, St. Louis; "An Experimental Approach to the Causes and Cures of Malignant Cell Proliferation"; Patricia McEwen, sponsoring teacher.

Initial presentation of the Union Electric Company Sponsor's Award was made to Edward Lee Spain, Hillcrest High School, Springfield. He presented a paper in the Engineering session based on his research on "Heliothermal Ram Solar Heater." Hugh Brewer was his sponsoring teacher.

In 1976, the MJAS was formally attached to the Missouri Academy of Science and officially became the Junior Division of the Missouri Academy of Science. The popular name, MJAS, however, continued in common usage. Several changes were made in membership of the administrative bodies of MJAS in 1976-77. On the Advisory Board, William L. McConnell, Webster College, St. Louis, replaced Ernest A. Dunning, North Kirkwood Junior High School, Kirkwood; and Charles Proctor, Union Electric Company, St. Louis, replaced Gerald E. Dreifke of the same company.

Changes of Co-Directors were made in 4 Districts. In District I (Southwest), Ernest Ferguson, Neosho High School, Neosho; and William Thomas, Southwest Missouri State University, Springfield, replaced Joe Tuck and

Bruno Schmidt. In District III (Northwest), Gerald Zweerink and Harry F. Force, Missouri Western State College, St. Joseph, replaced Kenneth W. Minter. In District V, Central, James Hoerter, Stephens College, Columbia, replaced Eugene A. Oshima; and, in District VI, Kansas City, James Hall, Barstow School, Kansas City, replaced Oneida Beeman.

The Third Decade: 1977-1984

The 1977 Annual State Meeting was held on the campus of the University of Missouri-St. Louis on April 29-30. Fifty-two students presented 50 papers given in 7 concurrent sessions; 2 papers were co-authored. All 7 Districts were represented by the 27 schools in which the students had carried on research supervised by 30 teachers.

The winner of the Science Teachers of Missouri plaque for the best presentation in each of the 7 sessions, the title of the winners' papers and the students' sponsoring teachers are:

Botany (8 papers)

Jery Platz, South Shelby High School, Shelby; "A Study of the Bleaching of *Euglena gracilis* Chloroplasts by Streptomycin"; Howard Platz, sponsoring teacher.

Chemistry (8 papers)

Lynn Bernal, Parkway West High School, Ballwin; "Kinetics of the Iodide-Peroxydisulfate Reaction"; Jean Ratcliff, sponsoring teacher.

Engineering, Mathematics, and Physics (8 papers)

Ken Williams, South Shelby High School, Shelby; "The Fourth Dimension and Beyond"; Howard Platz, sponsoring teacher.

Environmental Science (5 papers)

John D. Rainbolt, William Chrisman High School, Independence; "The Aggressive Tendencies in the Male *Mus musculus* as Individuals and in Colonies and How Changes in the Environment Affect the Aggressive Tendencies"; Oneida Beeman, sponsoring teacher.

General Biology (6 papers)

Leah M. Willson, Neosho High School, Neosho; "A Study of Fungi Found in Stalactites in Ozark Caves and Their Possible Effect on the Deposition of Calcite"; Ernest Ferguson, sponsoring teacher.

Microbiology and Medicine (8 papers)

Kevin Michael Clancy, Parkway West High School, Ballwin; "The Effects of *Agrobacterium tumefaciens* Strain K-84 on the Growth of Tumors in Kalenchol Plants"; Edward Schmidt, sponsoring teacher.

Physiology (7 papers)

Ann T. Eakes, Notre Dame de Sion High School, Kansas City; "Removal and Storage of Dog Blood for Autologous Transfusions"; Marlene McCall, sponsoring teacher.

Twenty-seven young women were nominated for the Dr. John Paul Morris Award. A tie vote resulted in dual awards to Glenda Farrar, LeBlond High School, St. Joseph, and to Nancy Seavage, Central High School, St. Joseph. Miss Farrar's research and paper were on "The Decaffeination of *Thea sinensis*," sponsored by Sister Mary Berchmans Bernadt. Miss Seavage's research and paper were on "Heavy Metal Accumulation in the Tissue of Marine Life Subjected to Primary Municipal Sewage Treatment Plant Effluent as Compared to Marine Life in a Clean Environment." She was sponsored by William McLaughlin.

Daniel Thorp, Ash Grove High school, Ash Grove, received the Union Electric Company Sponsor's Trophy for his presentation of "Maximum Efficiency of your Auto."

Five secondary school teachers were chosen by the District Co-Directors and the State Director as Outstanding Science Teachers in their respective Districts. These awards, given by the Junior Division of MAS, included commemorative plaques, expenses to the Annual Meeting and 1-year's membership in MAS. The honored teachers were:

Mrs. Renee Sucharski, Perryville High School, Perryville; District II, Southeast.
Sister M. Berchmans Bernadt, LeBlond High School, St. Joseph; District III, Northwest.
Mr. Howard Platz, South Shelby High School, Shelby; District IV, Northeast.
Mr. Lyle Alderson, Pittman Mills Jr. High School, Kansas City; District VI, Kansas City.
Mrs. Eva Kirkpatrick, Seckman Jr. High School, Imperial; District VII, St. Louis.

It was decided that from now on only one plaque per year will be given. From the district winners one will be singled out as outstanding. Mrs. Eva Kirkpatrick, Seckman Jr. High, C-6, Imperial, Mo., was given the Outstanding Teacher of Missouri Plaque, 1977, at ceremonies at the University of Missouri-St. Louis by Verlin Abbott, State Director.

During 1976 and 1977, 11 secondary school students received AAAS-MAS grants to help to pay for laboratory equipment and materials needed in their research projects. These awardees were:

Michael S. Clark, Hickman High School, Columbia.
Marlene Drag, LeBlond High School, St. Joseph.
Glenda Farrar, LeBlond High School, St. Joseph.
Mignon Makos, LeBlond High School, St. Joseph.

Marilyn Medved, Notre Dame de Sion High School, Kansas City.
 Debbie Riggs, Raytown South High School, Raytown.
 Mary Beth Ruddy, LeBlond High School, St. Joseph.
 Fred Saunders, LeBlond High School, St. Joseph.
 Douglas W. Sutter, Puxico High School, Puxico.
 Loren D. Wallen, Raytown High School, Raytown.
 Greg Weeks, Farmington High School, Farmington.

Dr. Charles Granger's period of service as State Director of MJAS had included 2 years of the uncompleted term of his predecessor and a full 3-year term. In accordance with the guidelines of the Junior Division, a new director was to be chosen. Mr. Verlin Abbott became the fifth State Director of MJAS at the 1977 Annual State Meeting in St. Louis. Mr. Abbott was one of the initiators of the Junior Academy and served on the Grant Committee in 1967 which sought financial support from NSF. Since that time, he had served on the original MJAS Committee as a representative from District VI, Kansas City, and as Co-Director of District VII, St. Louis. He also served as chairman of the Science Education Section of the Missouri Academy of Science. At the time he accepted the State Directorship, he was Science Coordinator for Parkway School District, St. Louis. At this same time, Dr. Granger became President-Elect of the Missouri Academy of Science.

When Verlin Abbott became State Director, his place as Director of District VII was taken by Sister Patricia Thro, Maryville College, St. Louis, and Eva Kirkpatrick, Seckman Junior High School, Imperial.

In 1977, the Missouri Academy of Science received a grant from the Allen P. and Josephine B. Green Foundation, which permitted the Academy to give financial support to high school and college undergraduate students for worthy research projects. The first of these awards, in 1978, for high school students went to:

Jeffrey Edgin, Southland Consolidated High School, Cardwell.
 Donna Masters, Southland Consolidated High School, Cardwell.
 Jerry Truitt, South Shelby High School, Shelbyna.
 Rebecca Turner, Hillcrest High School, Springfield.

AAAS/MAS grants to high school students during 1977-78 went to:

Sergio Alvarez, LeBlond High School, St. Joseph.
 Kathy Buhr, LeBlond High School, St. Joseph.
 Michael Clark, Hickman High School, Columbia.
 Rick Dickens, LeBlond High School, St. Joseph.
 Mark Dixon, Hartville High School, Hartville.
 Jeffrey Edgin, Southland Consolidated Schools, Cardwell.
 Donna Masters, Southland Consolidated Schools, Cardwell.
 Marilyn Medved, Notre Dame de Sion High School, Kansas City.
 David Moyer, LeBlond High School, St. Joseph.
 Chris Sams, LeBlond High School, St. Joseph.
 Fred Saunders, LeBlond High School, St. Joseph.
 Robert Stahlin, South Shelby High School, Shelbyna.
 Jerry Truitt, South Shelby High School, Shelbyna.
 Rebecca Turner, Hillcrest High School, Springfield.
 Terry Turner, LeBlond High School, St. Joseph.

The eleventh Annual State Meeting of MJAS was held on April 28-29, on the campus of Missouri Southern State College. Forty-three students from 28 schools, representing all 7 Districts, presented 41 papers. Two papers were co-authored and 30 supervisors guided these researches. An indication of the growing early interest and ability in science research were the 3 papers presented by junior high school students. Previously no more than 1 junior high school student had reached an Annual State Meeting.

Six Science Teachers of Missouri plaques were awarded to the following students who presented the outstanding paper in the respective sections.

Mathematics and Engineering (5 papers)

Steven Neese, Neosho High School, Neosho; "Can Computers Think?"; Ernest Ferguson, sponsoring teacher.

Physiology (7 papers)

Jane Dice, Liberty High School, Liberty; "Antibody Production in Mice after Receiving Sensitized Lymphocytes"; Gary McCollough, sponsoring teacher.

Chemistry (4 papers)

Robert Duncan, Central High School, St. Joseph; "An Investigation Concerning the Use of Half-Calcined Dolomite as an Absorber of Pollutant Hydrogen Sulfide Gas Liberated During Coal Gasification"; C.W. McLaughlin, sponsoring teacher.

Mark Dixon, Hartville High School, Hartville; "Applications of the Ames Salmonella Mutagenicity Test in Determining Chemical Carcinogenicity"; Marilyn Miller, sponsoring teacher.

General Biology (6 papers)

John Rainbolt, William Chrisman High School, Independence; "Heliconius Cyduo Spermetophores: Chemical Composition and Rate of Incorporation by the Female"; Oneida Beeman, sponsoring teacher.

Botany (5 papers)

Mark Dahmer, Nevada High School, Nevada; "The Effects of HPMS on the Growth, Cell Size, and Stomata Production of *Glycine max*"; R.M. Knoblauch, sponsoring teacher.

Ecology (5 papers)

Mary Gonzalez, Fox High School, Arnold; "An Analysis of Physiological Effects of Sulfur Dioxide on Common Species"; E. Kirkpatrick, sponsoring teacher.

Eleven nominations were made for the Dr. John Paul Morris Award. The award went to H. Michelle Bellos, Truman High School, Independence, for her research and paper on "Fire Retardants in Model Structures: Experiments in Timed Flammability." This research was supervised by Charles A. Nelson.

The Missouri Academy of Science honored 2 secondary school science teachers for their excellence in teaching and in advising their students in scientific research that led to competition in District and State Meetings of MJAS. The honorees, Mrs. Oneida Beeman, William Chrisman High School, Independence; and Mr. Harry Harnes, Rolla High School, received commemorative plaques, expenses to the Annual Meeting and a year's membership in the Missouri Academy of Science.

The American Association for the Advancement of Science awarded Honorary Student Memberships to 2 Junior Division members, Jane Dice, Liberty High School, Liberty; and Danielle Davis, LeBlond High School, St. Joseph. Jane Dice was selected to represent MJAS at the National AAAS Meeting in Dallas, Texas. These honorees also received an Honor Student Certificate and a year's subscription to *Science*.

During the 1978-79 academic year, changes were made in the Co-Directorships in 3 Districts. In District I, Dr. Robert Whitaker, Southwest Missouri State University, replaced Mr. William Thomas. Mrs. Kathy Lackey, Shelbina Junior High School, replaced Mr. Howard Platz in District IV; and Mr. Richard Henderson, Hickman High School, Columbia, replaced Mr. Howard Westerman in District V.

At the twelfth Annual State Meeting, Dr. Donald D. Jewell was given special recognition and commendation for his service as Co-Director of Southeast District II. He resigned after having served for 12 years since the first District Meeting was held in 1967. Dr. Carl Train, Southeast Missouri State University, replaced Dr. Jewell as Co-Director of District II.

The twelfth Annual State Meeting of the Junior Division was held in conjunction with the Missouri Academy of Science on April 27-28, 1979, on the campus of Lincoln University. The logistics of this meeting were facilitated by the efforts of 19 science students from Jefferson City High School. These students served as hostesses and hosts under the supervision of Mrs. Jean Stanford, biology teacher at that school.

Research papers were presented in 8 concurrent sessions by 36 students who represented 18 schools in all the 7 Districts. Twenty teachers supervised the research of these students. Presentors of 6 outstanding papers were given Science Teachers of Missouri plaques and a year's membership in the Missouri Academy of Science. These winners in their respective sessions were:

General Biology (6 papers)

Lee Ann Heman, William Chrisman High School, Independence, "Isolation of a Limiting Factor Involved in Host Specificity of *Heliconius charitonius* Larva"; Oneida Beeman, sponsoring teacher.

Microbiology (6 papers)

Stephanie Ann Suszko, Cor Jesu Academy, St. Louis; "The Role of Amino Acids in the Regeneration of *Dugesia dorotocephala*"; Sister Mary Jane Paoella, sponsoring teacher.

Physiology (7 papers)

Barbara L. Massey, Liberty High School, Liberty; "The Effect of Chlorpheniramine on Histamine-Induced Edema in the Mouse"; Gary R. McCollough, sponsoring teacher.

Physical Science (6 papers)

Greg Mears, Neosho High School, Neosho; "The Design and Construction of a Non-Metallic Solar Collector"; Ernest Ferguson, sponsoring teacher.

Chemistry (3 papers)

John Colombo, Central High School, St. Joseph; "An Investigation of the Adsorption Rate of Carbon Disulfide on Silicalite, a Molecular Sieve"; Mickey Seever, sponsoring teacher.

Earth Science and Ecology (3 papers)

Patrick McCarthy, Horton Watkins High School, Ladue; "The Correlation between the Size of Sunspots and their Random Drift Velocities"; Marvin Friedley, sponsoring teacher.

Barbara L. Massey, Liberty High School, was awarded the AAAS Student Membership and the trip to the AAAS annual meeting for her paper in physiology. Robert G. Krueger, Highland High School, Ewing, also received the AAAS Student Membership Award and was chosen as alternate to the AAAS annual meeting. His research on "The Use of Antioxidants for Protection of Tissue Cells from Ultraviolet Irradiation" was supervised by Rod Higgins.

The Union Electric Trophy and cash award for outstanding research concerning energy was won by Greg Mears, Neosho High School. A Union Electric cash award was also won by Donald F. Ernst, Lafayette High School, St. Joseph. His research on "Performance of a Concentrating Solar Collector Employing Flat Mirrors" was supervised by Michael Hollingsworth. Robert J. Boulware, Shelbina Junior High School, received the Sargent Welch Calculator Award for his paper concerning "The Effects of Environmental Factors on the Color Change of an Anole." This research was supervised by Kathy Lackey. Susan K. Weimer, Neosho High School, was chosen

from among 16 nominees for the Dr. John Paul Morris Award. Her research of an oscillating liquid system was directed by Ernest Ferguson.

The procedure for allotting AAAS research grants and the amount of each grant were changed in 1978. Previously, the Missouri Academy of Science had administered the program but henceforth it would be administered by the State Director of the Junior Division through the Junior Division of the Academy. The value of the grants changed from \$25 to \$30. Ten MJAS student members, chosen from 40 applicants, received research grants from AAAS/MAS during 1978-79. These were:

Doug Cadmus, Madison C-3 High School, Madison.
Jonathan E. Frazier, LeBlond High School, St. Joseph.
Jane A. Dice, Liberty High School, Liberty.
Bryan J. Ennis, Sacred Heart High School, Sedalia.
Mary Beth Esswein, Cor Jesu Academy, St. Louis.
Donald F. Ernst, Lafayette High School, St. Joseph.
Brad J. Broyles, Parkview High School, Springfield.
Steve W. Shier, Odessa Junior High School, Liberty.
Jonathan Thomas, Liberty High School, Liberty.
Deborah Guth, Fox High School, Imperial.

The Allen P. and Josephine B. Green Foundation renewed the 1977-78 grants that had been held by the following 4 MJAS student members:

Jeffrey Edgin, Southland C-Schools, Cardwell.
Donna Masters, Southland C-Schools, Cardwell.
Jerry Truitt, South Shelby High School, Shelbyna.
Rebecca Turner, Hillcrest High School, Springfield.

Mr. Gary McCollough, biology teacher at Liberty High School, was honored by Missouri Academy of Science as the state Outstanding Science Teacher in secondary schools. He was chosen on the basis of his classroom teaching, his guidance of students into independent research and his involvement with extensive summer field trips with students. In 1978 and 1979, 2 of his students were awarded trips to the AAAS Annual Meeting. Mr. McCollough's award included a commemorative plaque, expenses to the Missouri Academy of Science Annual Meeting and a year's membership in the Missouri Academy of Science.

The thirteenth Annual State Meeting of MJAS was held on April 24-25, 1980, on the campus of Northeast Missouri State University. All 7 Districts were represented by 22 schools from which 36 students presented papers. The presenter of the outstanding paper in each of 7 concurrent sessions received a Science Teachers of Missouri plaque. These winners, the titles of their papers and their sponsoring teachers were:

General Biology (5 papers)

Daniel Wayne Logsdon, Highland High School, Ewing; "Effect of Various Fat Diets"; Rod Higgins, sponsoring teacher.

Botany (6 papers)

Richard Redpath, Jr., Horton Watkins High School, Ladue; "The Effect of Coherent Light on Plant Growth."

Ecology and Earth Science (5 papers)

Peggy Sue Nelson, Highland High School, Ewing; "Determining if the Herbicide 2,4,5-Trichlorophenoxyacetic Acid Causes Birth Defects in Frog Embryos"; Rod Higgins, sponsoring teacher.

Physiology (6 papers)

Roger G. Krueger, Highland High School, Ewing; "Ultraviolet Radiation"; Rod Higgins, sponsoring teacher.

Microbiology (6 papers)

John Phillips, Southland High School, Arbyrd; "Identifying Potential Environmental Carcinogens Using a Mutant Strain of *Escherichia coli*"; Sherrill Williams, sponsoring teacher.

Mathematics (3 papers)

David Rankin, Lee's Summit High School, Lee's Summit; "Recognition of Visual Images from Imperfect Data"; Gary Comens, sponsoring teacher.

Physical Science and Engineering (5 papers)

David Kirschner, Central High School, St. Joseph; "The Use of Caster Bean Plants (*Ricinus communis*) as an Alternate Home Heating Source"; Bill McLaughlin, sponsoring teacher.

Traci David and Lora Whited of the Maryville R-II High School and supervised by Nancy Jensen, were co-recipients of the Dr. John Paul Morris Award. Traci David's paper was on "Regeneration," whereas Lora Whited researched the "Extraction of Antimicrobial Substances from the Seeds of Ornamental Peppers and the Leaves of the Common Marigold Plant." Donna Ruth Hawk, Ozark High School, Ozark, received the Union Electric Company Trophy and cash award for the best research and paper concerning energy. The title of her paper was "Solar Shower Power." The Bausch and Lomb Honorary Science Award was presented to Katherine L. Barnes, Central High School, St. Joseph, for her paper entitled "A Determination of the Production of Ethylene from Fruits and Its Importance in Affecting the Growth and Development of Plants." C.W. McLaughlin supervised the research which led to this paper. Peggy Sue Nelson, who had presented the outstanding paper in the

Ecology-Earth Science session, was selected to represent the Junior Academy. She presented her paper at the Annual Meeting of AAAS in Toronto, Canada, in January 1981. Mrs. Kathy Lackey, who teaches Earth Science and Life Science at Shelbina Junior High School, was named Outstanding Science Teacher in Missouri in 1980. She received a commemorative plaque and a year's membership in the Missouri Academy of Science which sponsors competition for this award.

Thirty-eight students from 21 secondary schools in 6 Districts presented 36 papers in 9 concurrent sessions at the fourteenth Annual State Meeting of MJAS. The meeting was held on the campus of Missouri Western State College in St. Joseph on April 24-25, 1981. Traveling plaques were presented by Science Teachers of Missouri to the 9 students who presented outstanding papers in their respective sections. These winning students and the titles of their research papers were:

General Biology (6 papers)

Penny Bestman, Palmyra High School, Palmyra; "The Effects of Oxytocin on the Regeneration of Planarians"; Susan Lomax, sponsoring teacher.

Botany (3 papers)

Karen Logsdon, Canton High School, Canton; "The Use of Electrophoresis in the Study of Three *Trifolium* Species"; Mary Feldkamp, sponsoring teacher.

Microbiology (5 papers)

John K. Phillips, Southland C-9 High School, Cardwell; "The Effects of Testosterone and Estrogen on the Aging Process of Human Male and Female Fibroblast Cells in Vitro"; Sherrill Williams, sponsoring teacher.

Zoology (5 papers)

Jeffrey D. Houghton, Highland High School, Ewing; "Determining if Natural Antioxidants Protect Frog and Mouse Embryos from the Effects of Radiation"; Rod Higgins, sponsoring teacher.

Social Science (3 papers)

Carol M. Happel, Palmyra High School, Palmyra; "Down's Syndrome: A Developmentally Disabled's Assessment"; Susan Lomax, sponsoring teacher.

Mathematics (2 papers)

Lei Ann Laster, Cooter High School, Cooter; "An Investigation of the Gaussean Integers"; Bernice H. Bullard, sponsoring teacher.

Physics (4 papers)

Montgomery Bohanan, Central High School, St. Joseph; "The Development and Production of a Low-Pressure, Low-Temperature Stacked-Plate Fuel Cell."

Chemistry (4 papers)

Cheryl L. Davidson, Central High School, St. Joseph; "The Separation of Reusable Polymer Resin from Common Waste Plastics Using Experimentally Determined Solvent Mixtures."

Ecology and Earth Science (4 papers)

Yvette Barera, Cor Jesu Academy, St. Louis; "Determining an Optimum Age for *D. magna* Toxicity Tests"; Sister Jude Ruggeri, sponsoring teacher.

The Dr. John Paul Morris Award was presented to Tammie Sue Rolofson, Lafayette High School, St. Joseph. Miss Rolofson displayed her scientific acumen by examination of "The Life Supporting Abilities of Sugar Derived from the Enzymatic Hydrolysis of Waste Paper." Mr. Eddie Davis presented the Union Electric Company Trophy for the best paper on energy to Montgomery Bohanan, Central High School, St. Joseph. The Auxillary to the American Veterinary Association presented an award to David L. Pulse, Liberty High School, for his paper in the Zoology section entitled "The Effects of Somatotropin on Healing." Lei Ann Laster received the AAAS Award and represented MJAS with the presentation of her research at the Annual Meeting of the American Junior Academy of Science and AAAS in Washington, DC, in January 1982. Miss Laster was a student at Cooter High School. John Phillips, Southland C-9 High School, Cardwell, was chosen as alternate representative.

A Science Merit Scholarship was awarded by MAS for the first time in 1981 to a secondary school senior. This scholarship was to "encourage those students interested in pursuing a career in science and recognize academic excellence in science and scholarship." Edward J. Hummer, a senior at Bishop LeBlond High School in St. Joseph, was the first winner of this scholarship. Charles W. McLaughlin, chemistry instructor and Science Department Chairman of Central High School in St. Joseph, was selected by the Missouri Academy of Science to receive the 1981 Outstanding Science Teacher Award. The award was presented by State Director Verlin Abbott. At the 1981 Annual State Meeting of MJAS, Dr. Dean Rosebery, President of the Missouri Academy of Science, presented Verlin Abbott with a Certificate of Appreciation for his 3-year term of service as State Director of the Junior Division. Dr. Adell Thompson, Department of Biology, University of Missouri-Kansas City, succeeded Mr. Abbott as State Director, and assumed his duties immediately. In January 1982 Mrs. Eva Kirkpatrick was appointed the first Associate State Director of the Junior Division of the Missouri Academy of Science. Mrs. Kirkpatrick was science teacher at Seckman Junior High School in Imperial and had been Co-Director of District VII (St. Louis) for the past 4 years, a position in which she continued. There were changes in the Co-Directorship of District VI (Kansas City), with the appointment of Dr. Adell Thompson to the State Directorship. Dr. Andrew Darton, Department of Science Education, University of Missouri-Kansas City, replaced Dr. Thompson. Jim Hall continued as Co-Director of District VI even though he also became unofficial Assistant to the State Director.

Other changes in District Directorships were made in 1982. Dr. William F. Thomas, Southwest Missouri State University in Springfield, replaced Dr. Robert Whitaker in District I. Robert Suits, Hickman High School, Columbia; and Dr. Gary Payton, William Woods College, Fulton, respectively, replaced Richard Henderson and James Hoerter in District V (Central).

The fifteenth Annual State Meeting of MJAS was held on April 23-24, 1982, on the campus of School of the Ozarks, Point Lookout. Forty students, representing 26 schools and supervised by 29 teachers in all 7 Districts, presented papers. The presenter of the outstanding paper in each of the 10 concurrent sessions received a traveling plaque from Science Teachers of Missouri. The winners, the titles of their papers and their sponsoring teachers were:

General Biology

Karen Louise Logsdon, Canton R-V High School, Canton; "The Use of Electrophoresis in the Study of Storage Proteins in *Agrostis alba*"; Mary Feldkamp, sponsoring teacher.

Botany

Annette E. Carnahan, William Chrisman High School, Independence; "An Analysis of Secondary Plant Product Dynamics"; Elizabeth A. McCoy, sponsoring teacher.

Microbiology

Susan R. Hayden, South Nodaway R-IV High School, Barnard; "The Effect of Five Different Antibiotics on the Growth of Bacterial and Yeast Infections from the Ears of Dogs"; Sue Nothstine, sponsoring teacher.

Physiology

David L. Pulse, Liberty High School, Liberty; "The Effects of Somatotropin on Healing"; Gary R. McCollough, sponsoring teacher.

Zoology

Marvin Maag, Salisbury High School, Salisbury; "Do Fish of Family Scorpaenidae Shed Their Skin?" Greg Thurman, sponsoring teacher.

Chemistry-Biochemistry

Janet E. Nelson, Central High School, St. Joseph; "Synthesis, Extraction, Characterization, and Allelopathic Effects of Juglone (5-hydroxy-1, 4-naphthoquinone)"; C.W. McLaughlin, sponsoring teacher.

Physics

Janet L. Harold, William Chrisman High School, Independence; "Can Flootation Exist between Soluble Substances at Varied Frequencies of Vibration"; Elizabeth A. McCoy, sponsoring teacher.

Mathematics

David Allen Betz, Neosho High School, Neosho; "An Investigation into Mechanical Game Playing"; Ernest Ferguson, sponsoring teacher.

Earth Science-Ecology

Yvette Marie Barera, Cor Jesu Academy, St. Louis; "Resolving a Practical Question Concerning *Daphnia magna* Toxicity Testing"; Sister Jude Ruggeri, sponsoring teacher.

Social Science

Paul B. Koch, Jr., Lafayette High School, St. Joseph; "Biorhythmic Study of Personal Accomplishers, Underachievers, and the Emotionally Distressed"; Bruce Taylor, sponsoring teacher.

Six of the 10 winners listed above competed for the AAAS award and the privilege of representing MJAS and presenting their research papers in the National Contest at the Annual Meeting of the American Junior Academy of Science in Detroit, Michigan, in January 1983. Yvette Marie Barera, Cor Jesu Academy, St. Louis, won the highest honor for her paper on Ecology. Janet E. Nelson, Central High School, St. Joseph, won second honors and was named alternate representative for her paper on Chemistry. Also, both these students received a Kirkpatrick Trophy from Eva Kirkpatrick and her husband, Raymond Kemps Kirkpatrick, given in honor of their children, Rodman Kemps and Becky Anne, who had participated in MJAS.

Stacey Fennewald, Bishop LeBlond High School in St. Joseph, received the Dr. John Paul Morris Award given each year to a young woman interested in science.

Other awards were given by the Navy League and the Missouri Veterinary Association Auxillary.

The Missouri Academy of Science selected Mrs. Glenda Carpenter as the Outstanding Science Teacher for 1982. Mrs. Carpenter taught chemistry, physics and physical science and was Science Department Chairman at Dexter High School. Dr. Adelle Thompson, as State Director of the Junior Division, presented the OSTA plaque to Mrs. Carpenter at the 1982 meeting of MJAS.

Several changes were made in the administration of the Junior Division in 1982-83. Dr. Loren Denny, Southwest Missouri State University in Springfield, replaced William F. Thomas as Co-Director of District I. Coincident with her retirement from teaching chemistry and physics at Bishop LeBlond High School in St. Joseph, Sister M. Berchmans Bernadt resigned from her Co-Directorship of District III, leaving her 2 colleagues, Gerald Zweerink and Harry F. Force as Co-Directors of the District. Mrs. Elizabeth Ann McCoy, William Chrisman High School in Independence, became Co-Director of District VII. She replaced Jim Hall who continued as Assistant to the State Director.

The 40 papers that won in the District's competitions were presented by their authors in 7 concurrent sessions at the sixteenth Annual State Meeting of MJAS on April 29-30, 1983, on the campus of St. Louis University in St.

Louis. Twenty-seven schools, distributed in all 7 Districts, were represented by the presentors of papers and their 30 sponsoring teachers. The presenter of the outstanding paper in each of the concurrent sessions received a Science Teachers of Missouri traveling plaque. These recipients were:

General Biology (6 papers)

Karen Stoll, Poplar Bluff High School, Poplar Bluff; "The Effects of the Administration of Furosemide on the Fetal Weight of Rats"; H.B. Starnes, sponsoring teacher.

Physiology (6 papers)

Heidi Prather, Liberty High School, Liberty; "Comparison of the Effects of Nonprescription Diet Pills Alone, in Excess, and Combined with Aspirin as Given to White Mice"; Gary McCollough, sponsoring teacher.

Zoology (6 papers)

Susan Rene Hayden, South Nodaway R-IV High School, Barnard; "An Observation of the Effects of Dimethyl Sulfoxide (DMSO) on the Striated Leg Muscle of a Frog"; Sue Nothstine, sponsoring teacher.

Physics (7 papers)

Don Wiltshire, Canton R-V High School, Canton; "Field-Effect Transistors"; Sharon Veatch, sponsoring teacher.

Chemistry (6 papers)

Richard Roberts, Central High School, St. Joseph; "The House Fly Pheromone: The Extraction, Synthesis, and Effectiveness Testing of Cis-9-Ticorene, the Pheromone of the *Mus domestica*"; C.W. McLaughlin and D. Reule, sponsoring teachers.

Ecology and Earth Science (5 papers)

Suzanne Ullensvang, John Burroughs High School, St. Louis; "Some Seasonal Ecological Characteristics of Sinking Creek"; Bruce Westling, sponsoring teacher.

Social Science (4 papers)

James Nimmo, Neosho High School, Neosho; "A Study in Auditory Perceptual Learning in Relation to an Instructor's Gender"; Robin Montz, sponsoring teacher.

The Navy League presented a briefcase as an award to Gregory Johnson, Hickman High School, Columbia, for his paper "Impact of a Municipal Waste-Water Lagoon on the Water Quality of a Missouri Stream." Richard Henderson and Robert Suits supervised Mr. Johnson's research.

Suzanne Ullensvang received the Dr. John Paul Morris Award of \$25 and a traveling plaque.

The AAAS Awards and the Kirkpatrick Trophies went to Richard Roberts and Suzanne Ullensvang. These students represented MJAS at the American Junior Academy of Science Annual National Meeting in New York in May 1984. They presented their research papers in national competition at that meeting.

The 1983 MAS Outstanding Science Teacher Award was presented to Mr. Denziel L. Bush by Adell Thompson, State Director of the Junior Division. Mr. Bush taught science at Kirkwood High School in Kirkwood.

The celebration of 50 years for the Missouri Academy of Science and 17 for MJAS was in 1984 at Cape Girardeau on the campus of Southeast Missouri State University on April 26 and 27.

Dr. Adelle Thompson, retiring State Director, presented the Outstanding Teacher Award to F. William Mayberry of Potosi High School, an Ecology and Outdoor Education teacher. Mrs. Elizabeth M. Shartzler of Liberty H.S. was runner-up. However, only one plaque is awarded.

Research awards of \$30 were presented to:

Gilbert Nelson, South Nodaway R-IV, Barnard, Mo.

Joanne Beattie, South Nodaway R-IV, Barnard, Mo. sponsoring teacher, Sue Nothstine.

Karen Stoll, Poplar Bluff H.S., Poplar Bluff, Mo., sponsoring teacher, H.B. Starnes.

Albert Chew, Carl Junction H.S., Carl Junction, Mo. sponsoring teacher, Mike Lawson.

The Kirkpatrick trophies went to Karen Stoll and Albert Chew. These students will represent MJAS at the American Junior Academy of Science Meeting in Los Angeles, May 1985. Albert Chew was presented a briefcase by the Navy.

Tina Chancey, Central H.S., St. Joseph, Mo., won the John Paul Morris Award.

Winners of the Science Teachers of Mo. division award plaques are:

Biology I (5 papers)

Stacey Allen, Liberty High School, Liberty, Mo.; "The Effects of Solomedral on the Growth of White Laboratory Mice"; Gary McCollough, supervising teacher, District VI.

Biology II (5 papers)

Karen E. Stoll, Poplar Bluff H.S., Poplar Bluff, Mo.; "The Effects of the Administration of Furosemide on the Placental Structure and Development of Rats"; supervising teacher, H.B. Starnes, District II.

Microbiology (6 papers)

Albert Fook Ming Chew, Carl Junction High School, Carl Junction, Mo., "The Characterization of a Conjugative R-Plasmid Found in a Newly-Isolated Wild-Type of *Escherichia coli*"; supervising teacher, Mike Lawson District I.

Ecology-Earth Science (5 papers)

Kelly Farnan—South Nodaway R-IV H.S., Barnard, Mo.; "The Effects of Nicotine and Other Water-Soluble Constituents of Cigarette Smoke on *Drosophila* spp. offspring"; supervising teacher, Sue Nothstine District III.

Chemistry (4 papers)

Todd A. Ramming, Saint Louis Priory, St. Louis, Mo.; "The Oxidation of Benzoic Acid by the Peroxydisulfate: An Investigation Through Rate-Determining Experiments"; supervising teacher, Joseph Gleich, District VII.

Physics-Math (4 papers)

David Steinhauser, Stanberry R-4 H.S., Stanberry, Mo.; "Mouse Control Language"; supervising teacher, Larry Maher, District III.

Since the Social Science Plaque is now filled, a new one donated by Eva Kirkpatrick was presented to:

Social Science (5 papers)

Toby Cole, Neosho H.S., Neosho, Mo.; "The Relationship of a Self-Rating of Introversion-extraversion to a Test's Evaluation of Several Personality Traits"; supervising teacher, Robin Montz, District I.

It was decided by Executive Committee the retired plaques would go to the student whose name appeared on it the most or in the case of a tie, the first one to respond in favor of accepting it. This was accepted until a better solution could be proposed.

Botany Plaque was given to Rodman Kirkpatrick in Houston, Texas, an enhanced Recovery petroleum engineer for Houston Natural Gas.

Social Science plaque, Physical Science and Zoology Plaques are now filled and will have to be replaced.

A symposium on the infamous New Madrid Fault of Southeast Missouri was held with 17 national earthquake experts presenting current views.

In this atmosphere of distinguished scientists, professors and interested colleagues the Junior Division District Directors and Advisory Council met and elected for the first time in their history a woman as State Director, Eva Kirkpatrick, chosen by National Science Teachers Association as a National Science Exemplar in Inquiry, and a physical science teacher at Seckman Jr. High C-6, Imperial, Mo. Dr. John Settlege of Northeast Missouri State U.—Kirksville was elected Associate Director.

The District Co-Directors are:

Southwestern

Mr. Mike Lawson, Carl Junction High School, Carl Junction, Mo.
Dr. Loren Denny, Southwestern Mo. State U., Springfield, Mo.

Southeastern

Mr. Ed Sebaugh, Jackson H.S. Reorganized School Dist. 2, Jackson, Mo.
Dr. Carl Train, Southeast Mo State, Cape Girardeau, Mo.

Northwestern

Dr. Gerald Zweerink, Mo. Western State College, St. Joseph, Mo.
Dr. John Roskin, Mo. Western State College, St. Joseph, Mo.

Northeastern

Mrs. Kathy Lackey, Shelbina Jr. High School, Shelbina, Mo.
Dr. Randall Emmons (who replaced Dr. Settlege), Northeast Mo. State U., Kirksville, Mo.

Central

Mr. Bob Suits, Hickman High School, Columbia, Mo.
Dr. Gary Payton, William Woods College, Fulton, Mo.

Kansas City

Mr. Gary McCollough, Liberty High School, Liberty, Mo.
Dr. Andy Darton, University of Mo., Kansas City, Mo.

St. Louis

Mrs. Marie Sherman, Ursuline Academy, St. Louis, Mo.
Sister Patricia Thro Ph.D., Maryville College, St. Louis, Mo.

The newly appointed Advisory Board consists of 15 members to be approved by Council meeting and Directors in April 1985. The emphasis is to include more business corporations on the board that sponsor MJAS.

Members are:

Chairman: U.S. Representative Bill Emerson, 8th District Mo, Cape Girardeau, Mo; Washington, D.C.
Eddie G. Davis, Supervisor, Community Affairs, Union Electric Company, St. Louis, Mo.
Dr. James I. Spainhower, President, Lindenwood College, St. Charles, Mo.
Dr. Charles J. McClain, President, Northeast Mo. State University, Kirksville, Mo.
Dean A. Rosebery, President, National Association of Academies of Science, Head, Division of Science NMSU, Kirksville, Mo.
Dr. Charles Granger, Biology Chairman, University of Mo, St. Louis, Mo.

Mrs. Kay McNulty Armstrong, Regional Program Director, National Energy Foundation, Mission, Kansas.
Dr. Albert Gordon, Past-Pres. Mo Academy of Science, Southwest Mo. State University, Springfield, Mo.
Dr. Charles E. Hudson, Superintendent of C-6 District, Arnold, Mo.
Dr. Richard L. King, Coordinator of Curriculum, Department of Elementary/Secondary Education, Jefferson City, Mo.
Sister Jude Ruggeri ASC, American Junior Academy of Science Representative, Cor Jesu Academy, St. Louis, Mo.
Mr. James J. Rickman, Past Superintendent of C-6 District, Arnold, Mo.
Mrs. Shirley Stoll, Vertebrates-Rules Advisor, Poplar Bluff, Mo.
Mr. Kevin W. Albritton CLU, First Financial Group of St. Louis, Inc., St. Louis, Mo.
Dr. Adell Thompson, Past State Director-MJAS, University of Mo., Kansas City, Mo.

Carter Dunkin of Southwestern Bell Telephone asked to remain a "silent" advisory. He along with Eddie Davis and D. Granger contributed much to the contents of the soliciting letter, and financial statement.

With a budget of \$19 the new director embarked on a 3-year financial update of MJAS. The summer was spent choosing the Advisory Board and preparing a list from Standard and Poor (at the suggestion of Mr. Dunkin) of 180 prospective donors among Missouri corporations and foundations, who might contribute to MJAS. It was voted by the Executive Committee in February '85 to put MJAS and the Collegiate Division under the financial umbrella of MAS. From now on any money collected by MJAS goes to MAS and is withdrawn by a budget financial sheet presented by the State Director.

In September 1984 Mrs. Kirkpatrick began negotiations with National Energy Foundation which ended in January 1985 with NEF becoming a substantial donor (\$3000) to MJAS, giving both an Energy Trophy and an expense-paid trip to New York to compete for scholarships in the Student Exposition on Energy Resources, an educational program sponsored by NEF to develop increased understanding among senior and junior high school students of the current energy situation and how to improve it. The \$3000 is to be used on Energy activities and students only. Mo SEER became an actuality. Other donors are Union Electric, Southwestern Bell Telephone, Rotary of Arnold, MO, Kevin Albritton, Rodmon Kirkpatrick, Jewel Niemon, Kiwanis of Arnold, MO, Jr. Academy of Science, Ringo Corporation of Ironton, & R.K. Kirkpatrick—a total so far of \$5258.

New professional, visually striking brochures were published with a picture from NASA of Earth RISE by Apollo II Crew, suggested by Dr. Granger as representative of present scientific technologies. It was supplied by Dr. Carolyn Summers of Houston, a teacher of the Astronauts. Dr. Settlege Ass. Director Shirley Stoll Adv. Board and Mary Mongold of Union Electric contributed much to the success of the brochure. Arrangements are being made by the State Director to fill out application forms for Metropolitan Association for Philanthropy, an agency to assist donors by compiling objective information on the variety of non-profit agencies. In other words they vouch for our integrity when foundations and donating sponsors contact them about us. It is almost an essential before foundations consider us. MJAS for the first time is being put on a financial business basis.

On to Southwest State University and the symposium and State Meeting of 1985.

**The 1984 Annual Meeting
of the
Missouri Academy of Science
April 27-28, 1984
Southeast Missouri State University
Cape Girardeau, MO**

Senior Division

Agriculture

Anglen, J. M., Central Missouri State University, Warrensburg, MO 64093. THE USE OF CREEP FEED TO PRODUCE A HEAVIER (4-6 POUND) RABBIT AT A WEANING TIME OF 56 DAYS. Creep feed has been shown to increase weaning weights of cattle and sheep, shortening the amount of time until the animal is ready for slaughter. This study was to see if a similar trend could be produced in meat rabbits of the Californian breed. Only a few rabbits in the entire study reached the expected weight of 4-6 pounds. This result is not similar to that of an earlier study using New Zealand White rabbits, but they had a higher protein level in their feed.

Biology

Herbst, B. A. and F. T. Janzow, Southeast Missouri State University, Cape Girardeau, MO 63701. THE ROLE OF THE TRUNK LATERAL LINE IN ORGANIZING DYADIC DOMINANCE ENCOUNTERS IN MALE *LEPOMIS MEGALOTIS* RAFINESQUE. A study was completed to determine if enervation of the trunk lateral line system would affect dyadic dominance encounters in male *Lepomis megalotis* Raf. We found that nearest-neighbor distances for parallel swimming and mean total frequencies of parallel swimming, head-to-tail tailbeating, circling and mouthfighting were statistically significant. The treatment effect had an additive effect in Sham and Operated pairs. All 3 groups (Control, Sham and Operated) appeared to exhibit behaviors which are fixed action patterns. Behavioral organization of parallel swimming, head-to-tail tailbeating, circling and mouthfighting may reflect the animal's attempt to optimize interactions required to establish dominance.

Dallali, A. and D. F. Millikan, Department of Plant Pathology, University of Missouri, Columbia, MO 65211. EFFECTIVENESS OF BIOLOGICAL AND SEROLOGICAL TESTS FOR DETECTING LATENT VIRUSES. Biological and serological tests are used to detect latent virus infections for virus certification programs. Biological tests involve transmission by grafting or mechanical means. Serological tests involve the use of antisera prepared by injecting a warm blooded animal with purified virus. The biological tests are accurate but require a long incubation period and extensive greenhouse space. Serological tests require a short period of time but are quite specific. When we tested 208 isolates which were positive on *Prunus tomentosa*, all were positive on cucumber but only 155 were positive by the ELISA test. When the 43 ELISA-negative isolates were checked by gel diffusion, 27 were positive. These observations indicate that the biological tests are more accurate for detecting latent viruses but the serological tests can be used for preliminary screening.

Doudrick, R. L., D. F. Millikan, M. F. Brown and J. A. White, Department of Plant Pathology, University of Missouri, Columbia, MO 65211. ROSE STRUCTURE AS IT RELATES TO THE MICROSCOPIC SYMPTOMS OF ROSE ROSETTE AND THE CAUSAL AGENT. Abnormal growth and coloration of leaves, flowers and shoots are typical symptoms of the rose rosette disorder. Affected tissues are only slightly altered but there is extensive development of pigmented substances in the vacuoles of epidermal cells of the affected organs. Sclerenchyma fibers associated with the phloem tissue are reduced or absent in the infected garden rose "Queen Elizabeth." This contrasts with the heavy-walled sclerenchyma found in healthy tissue. Other ultrastructural abnormalities were not detected, either by scanning or transmission electron microscopy.

Doudrick, R. L., D. F. Millikan, M. F. Brown, Department of Plant Pathology, and **D. A. Kinden**, College of Veterinary Medicine, University of Missouri, Columbia, MO 65211. THE INVESTIGATION TO DETERMINE THE

CAUSAL AGENT OF ROSE ROSETTE. Reddening of leaves and shoots, abnormal floral development and witches'-broom are characteristic symptoms of rose rosette disorder of roses. The rose rosette agent is readily transmitted by grafting to other species or cultivars of rose but not to other genera of the Rosaceae family. Methods other than grafting to transmit the disease agent have been unsuccessful and no vector other than man has been identified. The eriophyid mite, *Phyllocoptes fructiphilus* Keif. routinely is associated with roses displaying symptoms of rose rosette but tests have failed to confirm its role in the etiology. Efforts to minimize the impact of the disorder on rose have been ineffective thus eradication remains the only effective control measure.

Stefan, S. J. and D. F. Millikan. Department of Plant Pathology, University of Missouri, Columbia, MO 65211. **REDUCTION OF BROWNING DURING STATE 1 IN EXPLANTS OF SOME WOODY PLANT SPECIES.** Previously we introduced modifications in procedures and media formulations which minimized the lethal browning action in black walnut, *Juglans nigra*. These techniques have been tested with 2 additional members of Juglandaceae (*J. cinerea* and *J. regia*) and 3 species of Fagaceae (*Castanea dentata*, *Quercus alba* and *Q. rubra*). *Juglans regia* and *J. cinerea* had less browning when both Na DIECA (Sodium diethylthiocarbamate) and PVP (Polyvinylpyrrolidone) were used. Preliminary results with the species of Fagaceae suggest a similar pattern. *Juglans regia*, *J. cinerea* and *C. dentata* had superior growth on ½ strength Anderson's medium while the other species did as well or better on ½ MS medium. These data indicate that PVP and Na DIECA have widespread implications for reducing browning in woody species but media modifications are species specific.

George, M. F., M. R. Warmund and D. F. Millikan. Department of Plant Pathology, University of Missouri, Columbia, MO 65211. **EFFECTS OF LOW TEMPERATURES ON SOME HARDY CLONES AND COMMERCIAL CULTIVARS OF PEACH.** Seed from peach clones which have survived -38-40 C in northwest China were germinated in 1981. One year old scions of these seedlings and those of July Elberta, Loring and Redhaven were submitted to artificial freezing tests in January 1984. The Chinese material survived exposures of -31 C with slight xylem discoloration and no bark injury. Exposure to -35 C, however, resulted in death to the xylem tissue and extensive bark injury. Xylem tissue of the commercial cultivars was killed by exposure to -20 C. These cultivars, however, were damaged in the field by exposure to -26.5 C whereas the Chinese were not. These observations identify a high level of resistance to low temperatures which can be used to incorporate winter hardiness into peach cultivars.

Welton, T. D. and G. D. Sells, Northeast Missouri State University, Kirksville, MO 63501. **EFFECT OF KAEMPFEROL ON RESPIRATION OF MITOCHONDRIA ISOLATED FROM MAIZE SHOOTS.** Water stress has been previously shown to affect mitochondrial respiration of proline differently from that of other typical substrates such as succinate, malate + pyruvate (M+P) and exogenous NADH. With moderate stress proline oxidation decreases exponentially while oxidation of other substrates decreases gradually. Kaempferol, aflavone constituent of many plants, has been postulated as a substance which may mediate the differential responses of mitochondria to stress. Results of our study indicate that kaempferol in the range of 5 to 25 x 10⁻⁵ M reduces respiration rates of all substrates studied. The degree of inhibition, however, was much greater when proline and M+P were being oxidized than when succinate and exogenous NADH were being oxidized.

Dwyer, J. D. Department of Biology, St. Louis University. **THE ANGIOSPERM FAMILY, RUBIACEAE.** This angiosperm (Madder Family or Coffee Family), on a world-wide basis, has about 8000 species in about 500 genera, mostly tropical. In Missouri there are 8 genera and about 26 species, virtually all of which are herbs or vines. In tropical Mesoamerica 5 of the 8 genera are present, the total number of Rubiaceae in Mesoamerica being approximately 1600 species in 225 genera. Almost all of these are trees or shrubs. The influence of environmental factors in the tropics, principally temperature fluctuations and fluctuations in water available, are discussed. Adaptations made to the biomes characterizing the tropics, e.g. the rain forest, are discussed with special relation to the Rubiaceae, usually the dominant dicot family in the wettest parts of the tropics.

Halbrendt, J. M. and V. H. Dropkin, Department of Plant Pathology, University of Missouri, Columbia, MO 65211. **HYDROPONIC INVESTIGATIONS ON COMPATIBLE AND INCOMPATIBLE SOYBEAN CYST NEMATODE (SCN) - SOYBEAN INTERACTION.** Two SCN populations, each selected and inbred on a resistant soybean line (PI 209332 or PI 89772), were inoculated in compatible and incompatible combinations, i.e. on their selecting and non-selecting hosts respectively. Synchronous nematode development was attained by growing roots of 3 day old plants in infested soil for 24 hours after which they were washed and transferred to test tubes of deionized water. Cotyledons were pruned to ¼ of their volume and each test tube received aeration through a pasteur pipette connected to an air pump. After 15 days at 27 C under 14 hour/day of fluorescent light, the roots were stained and cleared for examination. All nematodes were rated according to their stage of development. Both compatible combinations produced a high percentage of mature nematodes while the incompatible combinations showed a high degree of arrested development; each combination apparently blocking SCN maturation at a different stage.

MacAdam, J. W. and C. J. Nelson, Department of Agronomy, University of Missouri, Columbia, MO 65211. **EVALUATION OF CHANGE IN SPECIFIC LEAF WEIGHT OF ELONGATING TALL FESCUE LEAVES.** The elongating leaf blade of tall fescue (*Festuca arundinacea* Schreb.) displays a linear increase in specific leaf weight (SLW) in the region of cell maturation. The objective was to identify the site of this change in SLW, quantify it and relate it to previously identified regions of cell division and elongation. Vegetative tillers of genotypes selected for low (LYT) and high yield per tiller (HYT) were grown in growth chambers at 17, 20 and 25 C. Elongating leaf blades were removed from the plant crown at the point of attachment and cut into consecutive segments of equal

length for analysis. It was found that SLW is minimal at that point in the elongating leaf blade where cell elongation ceases and cell maturation begins. Secondary cell wall deposition is revealed as a linear increase in structural SLW (SLW-water soluble carbohydrates), and occurs for a longer time period in the HYT genotype than in the LYT genotype, contributing to a higher SLW in mature leaves of the HYT genotype.

Wallin, J. R., Department of Plant Pathology, USDA, ARS, University of Missouri, Columbia, MO 65211. THE INFLUENCE OF *ASPERGILLUS FLAVUS* ON THE AFLATOXIN LEVELS OF CUT VS. WHOLE, WASHED AND UNWASHED MAIZE KERNELS. Cut and whole kernels of composite population Ibadan "B", Mo17H, Mo20W, N141 and Oh3A inbred lines were challenged with 10,000 conidia/ml, incubated 8 days at 28 C. The kernels were removed and 1 of each treatment was washed or not washed (rinsed). After the rinse, the kernels were dried, ground and analyzed for aflatoxin B1. Rinse water from each treatment was analyzed also. The cut, unwashed kernels had much higher aflatoxin levels than the cut washed or whole kernels, washed and unwashed, for all genotypes, except Mo20W. Ibadan "B", whole kernels not washed had the lowest content, 168 ppb, and N141 had the highest, 1260 ppb, cut, unwashed. Whole unwashed kernels infected with *A. flavus* can have medium levels of aflatoxin B1.

Kelly, S. M., Plant Pathology Department, University of Missouri and **J. R. Wallin**, USDA, ARS, and Plant Pathology Department, University of Missouri, Columbia, MO 65211. DISCREPANCIES IN AFLATOXIN CONTENT OF CORN GENOTYPES INOCULATED WITH *ASPERGILLUS FLAVUS* IN THE LABORATORY AND IN THE FIELD. Kernels of 13 corn belt inbreds X *Zea diploperennis* (diploid perennial teosinte) backcrossed to the inbreds were surface sterilized with 2% sodium hypochlorite, decapped, inoculated with *A. flavus* and incubated 8 days in moist petri dishes at 28 C. They were removed, dried at 60°C, ground and analyzed for aflatoxin levels. Aflatoxin was not detected in the kernels from some ears of B73 X (maize X *Zea diploperennis*) which contained 6,300 and 23,000 ppb in field inoculated material. Pa405⁴ X *Zea diploperennis* which contained 400 ppb in field inoculated kernels contained 1,590-2,393 ppb in the petri dish test kernels. The search for genetic control is complicated by these and other inconsistencies to be cited herein.

Stauffer, C. S., Plant Pathology Department, University of Missouri, and **J. R. Wallin**, USDA, ARS and Plant Pathology Department, University of Missouri, Columbia, MO 65211. SEARCH FOR GENETIC CONTROL OF A *ASPERGILLUS FLAVUS* AND AFLATOXIN LEVELS IN TWO EXOTIC POPULATIONS OF MAIZE. Two exotic composite population consisting of flint-dint types, Cateto and Caribbean Flint-Dent, adapted to the Corn Belt were challenged in Petri dishes, 200 kernels each population, with 2000 *A. flavus* conidia per ml. After 6 days incubation at 28 C, the survivors were transplanted to peat pots for transplanting to the field for subsequent inoculation of the mature ears. The 1983 results and plans for 1984 will be discussed.

Bio-medical

Chavis, D. D. and R. R. Anderson, University of Missouri, Columbia, MO 65211. EFFECTS OF THE COLLAGEN GEL MATRIX ON VIABILITY OF MAMMARY EPITHELIUM IN VITRO. Maintenance of viable epithelium in vitro has long been a challenge. In contrast to the more tenacious fibroblast, epithelium grown on a plastic or glass surface will lose viability soon after attachment has taken place. With the advent of the collagen gel, the attachment dependence factor has been served while maintaining cell viability. This experiment compares the changes taking place in mouse mammary epithelial cell cultures grown on collagen to those grown on plastic dishes. The methods of measuring these changes are: 1) observing morphological changes at a microscopic level and 2) a dye exclusion viability test using erythrosin B.

Palomo, T. and R. R. Anderson, University of Missouri, Columbia, MO 65211. HYDROXYPROLINE AS A MEASURE OF COLLAGEN IN REPRODUCTIVE TISSUES: MAMMARY GLAND, UTERUS, CERVIX AND PUBIC SYMPHYSIS. Collagen content was measured in tissues of goats and guinea pigs. In goat mammary glands, the dry fat-free tissue was composed of 51% collagen in the virgin. It dropped gradually during pregnancy to 36% at 90 days and to 20% at 145 days. It was 17% 1 day prior to parturition and 24% on the first day of lactation. It remained at approximately this percentage through the first 90 days of lactation: 27% on day 5, 24% on day 10, 23% on day 15, 28% on day 30 and 22% on day 90. After 3 months of involution, the gland was back to 48% collagen. In guinea pigs, collagen content was measured in mammary glands of animals ranging in age from 30 days to over 200 days. The collagen content remained at approximately 25% throughout this age range. During lactation the mammary gland had 5 to 8% collagen. When lactation was not permitted after a normal pregnancy, the gland was 12% collagen at 5 days of involution, 22% at 30 days and 29% at 40 days involution.

Sheffield, L. G. and R. R. Anderson, University of Missouri, Columbia, MO 65211. INSULIN, GROWTH HORMONE AND PROLACTIN ON MAMMARY FIBROBLASTS CULTURED IN VITRO. Various concentrations of hormones were used in this study. Insulin (30 µg/ml) increased DNA synthesis to 130% of control as measured by uptake of tritiated thymidine. Growth hormone at 300 ng/ml produced an optimal response. Insulin and growth hormone together at 20 µg/ml and 250 µg/ml, respectively, doubled uptake of thymidine. Prolactin at 350 ng/ml resulted in thymidine uptake at 85% of control. Prolactin appears to suppress formation of mammary stroma, while it is known to stimulate mammary epithelia. Insulin and growth hormone are stimulatory to DNA synthesis by fibroblasts and probably in this way stimulate incorporation of collagen into mammary stroma.

Akasha, M. and R. R. Anderson, University of Missouri, Columbia, MO 65211. CONCENTRATION OF THYROXINE (T₄) AND TRIIODOTHYRONINE (T₃) IN DAIRY CATTLE SERUM AT 3 STAGES OF LACTATION.

Eighteen lactating Holstein cows were selected with 6 each in early, middle and late stages of lactation. Blood samples were obtained on 7 successive days. Blood serum was measured by RIA. There were significant differences at the 3 stages of lactation ($P < 0.05$) in serum T_4 which tended to increase with stage of lactation (50, 55, 61 ng/ml, respectively). However, there were not significant differences ($P > 0.05$) in serum T_3 . Milk production was significantly different ($P < 0.01$) at the 3 stages of lactation (29.1, 23.2 and 13.6 kg/day). Since T_4 in blood is bound to thyroxine binding globulin, it appears that secretion of T_4 from the thyroid is in relatively short supply in early lactation and does not equal the demand by cells until late lactation.

Robbins, W. K. and G. D. Sells, Northeast Missouri State University, Kirksville, MO 63501. EFFECT OF WATER STRESS ON RESPIRATION OF MITOCHONDRIA ISOLATED FROM RAT LIVER. Furosemide, a diuretic, was administered by intravenous injection or by gavage to white rats weighing between 200 and 400 grams. Following a 24 hour stress period the hematocrits were determined and the rats placed in 3 groups. Nonstressed controls were designated by 'crits of 47 while rats with 'crits of 55 and 63% were classed as moderate and severe, respectively. Respiration of mitochondria were measured by use of an oxygen electrode. State III and IV rates during oxidation of succinate increased; however, the ADP/O ratios decreased. In contrast the respiration rates during oxidation of proline did not change significantly with stress. A significant increase in the ADP/O ratio was observed during oxidation of proline.

Dubriwny, D. and O. B. Mock, Northeast Missouri State University and Kirksville College of Osteopathic Medicine, Kirksville, MO 63501. PANCREATIC ISLET MORPHOLOGY IN THE DIABETIC LEAST SHREW. Studies concerning the morphology of the pancreatic islet cells were undertaken as part of a program to determine the appropriateness of the least shrew (*Cryptotis parva*) as an animal model for diabetes mellitus research. In animals that had not shown glycosuria or hyperglycemia, islet cells accounted for less than 1.7% of the total pancreatic tissue. Hyperplastic islet tissue represented up to 12% of the total pancreatic mass in diabetic shrews. No animal with normal distribution of islet tissue had plasma insulin levels above 100 μ U/ml. Hyperinsulinemia was present in all shrews with high islet counts. Hyperglucagonemia was present in most shrews tested ($x = 23.5$ ng/ml). No correlation between islet hyperplasia and elevated plasma glucagon was obvious. Immunoperoxidase histologic methods were positive for both hormones. Staining intensity for insulin increased with increased plasma levels. Few glucagon containing cells were present even in animals with high glucagon levels indicating a possible extrapancreatic site for glucagon production.

Goddard, J. J. and O. B. Mock, Northeast Missouri State University and Kirksville College of Osteopathic Medicine, Kirksville, MO 63501. DIABETES MELLITUS IN THE LEAST SHREW. The main objective of this research is to determine the value of the least shrew as an animal model for noninsulin-dependent diabetes mellitus research. Glycosuria is first observed in animals 3-9 months old and remains for 3-5 months, then urine glucose returns to and remains at low levels. Shrews with glycosuria are also hyperglycemic; however, the converse is not necessarily true. After a long period of glycosuria, shrews show polyuria which remains even if the urine glucose returns to low levels. Hyperglycemic animals show elevated insulin and glycagon readings. By carefully monitoring the shrews and collecting histologic samples we hope to better understand the characterization of the diabetes observed in the shrew. This research will determine also the genetic factor involved.

Mohammed, M. E. and H. D. Johnson, University of Missouri, Columbia, MO 65211. EFFECTS OF HORMONE SUPPLEMENT ON PHYSIOLOGY OF CATTLE UNDER HEAT STRESS. The responses of milk production and other physiological functions to growth hormone (16.6 mg/day) and triiodothyronine (5 mg twice daily) injections were studied in 2 different groups of Holstein cows in mid-lactation under heat stress. The objective was to determine if hormone supplementation would alleviate the heat induced declines in milk production during heat stress. Growth hormone administration during heat resulted in an increase in milk production by 8.0%, milk fat yield by 13%, a decrease in feed intake by 6.2% and an elevation of rectal temperature by 0.1 C with no significant change in body weight. T_3 injection under heat stress did not increase milk production significantly. Feed intake, energy metabolism and body weight were reduced but total animal vaporization was significantly increased over controls.

Igono, M. O. and H. D. Johnson, University of Missouri, Columbia, MO 65211. INFLUENCE OF A SEROTONINERGIC ANALOGUE ON VAPORIZATION DURING HEAT STRESS. The effect of trifluoromethyl phenyl piperazine (TFMPP), a serotonergic agonist on evaporative heat loss in Holstein heifers during moderate heat stress was measured to derive benefits for lactation performance in hot climates. Holstein heifers, 1 year old, were housed in the Climatic Laboratory under thermoneutral (20-22 C; 55-60% RH) and acclimated to moderate heat (28-30 C; 40-45% RH) conditions for 2 or 4 weeks, respectively. Feed and water were available free choice and rectal temperatures (T_{re}) measured twice daily. Prior to administration of TFMPP, basal vaporization rates were determined using a dew point hygrometric tent method. Following this, TFMPP was injected subcutaneously behind the scapula. Evaporative heat loss was measured at 30 min and hourly intervals thereafter postinjection for 6-8 hours. Rectal temperature during thermoneutral averaged 38.8 C compared to 39.9 C during moderate heat stress. TFMPP increased evaporative heat loss 20-30% for 8 hours after injection.

Mitra, R., D. Peckham, P. Erhart and J. B. Durham, University of Missouri, Columbia, MO 65211. IMMUNOASSAY OF CREATINE PHOSPHOKINASE MB FRACTION (CPK-MB). CPK-MB is a significant marker for cardiac muscle damage. Testing for this enzyme in patient's serum is important in the diagnosis and follow-up of myocardial infarction. Conventional enzyme analysis involves electrophoretic or chromatographic separation of CPK-MB from its isoenzymes, CPK-MM and CPK-BB, and subsequent kinetic assessment of the MB isolate.

Recently, a direct immunoassay has been introduced that does not require sample fractionation. We have compared the Worthington ion-exchange kinetic assay with Hybritech's immunoassay in a clinical study. These two assays give results in activity and mass units respectively, which complicates method comparison. However, a review of patient status shows a high degree of sensitivity and specificity in the immunoassay method. This may be due to Hybritech's use of monoclonal antibodies to measure the intact CPK-MB molecule. Immunoassay of the enzyme mass also alleviates the effects of time, temperature and fractionation conditions that are potential sources of variation in the kinetic assay.

Cornell, R. P., Northeast Missouri State University, Kirksville, MO 63501. GUT-DERIVED BACTERIAL ENDOTOXIN ELICITS THE SECRETION OF HEPATOTROPHIC FACTORS DURING LIVER REGENERATION IN RATS. This laboratory has proposed that bacterial endotoxin derived from the gut may initiate liver regeneration by eliciting the secretion of hepatotrophic factors such as insulin, glucagon, epidermal growth factor, vasopressin, insulin-like growth factor I, etc., following partial (67%) hepatectomy of rats. Systemic endotoxemia was detected by Limulus lysate gelation tests (Pyrogen, Mallickrodt) in the extracted plasma of male Holtzman rats at 12, 18, and 24 hour after partial (67%) liver resection but not sham surgery under ether anesthesia. The presence of gut-derived endotoxin in the systemic circulation is thought to be due primarily to failure of normal Kupffer cell phagocytosis following $\frac{2}{3}$ liver removal. Changes in the portal and systemic plasma levels of the hepatotrophic factors were similar in partially hepatectomized rats compared to animals given a small intravenous dose (33 μ g/100 g) of Salmonella enteritidis endotoxin. (Supported by American Diabetes Association)

Chemistry

Watin, R., K. Sakamachi and L. Smith, Southeast Missouri State University, Cape Girardeau, MO 63701. THE ENTHALPY OF IONIZATION OF THIOCYANIC ACID BY FLOW MICROCALORIMETRY. The ionization constant of thiocyanic acid in aqueous solution has been determined by potentiometric titration at several ionic strengths. The enthalpy of ionization has been determined by titration calorimetry at 0.50 ± 0.03 kcal/mole at an ionic strength of 0.49. In order to determine the enthalpy of ionization at lower concentrations, it was necessary to make measurements on a LKB flow microcalorimeter. The results at ionic strengths of 0.10 and 0.020 will be presented.

Chan, L.-C., J. Campbell and R. L. Smith, Southeast Missouri State University, Cape Girardeau, MO 63701. THE THERMODYNAMIC PARAMETERS FOR THE COMPLEXATION OF SODIUM AND FLUORIDE IONS IN AQUEOUS SOLUTION. A calorimetric and potentiometric investigation has been carried out to measure the equilibrium constant and the enthalpy of association of sodium and fluoride ions in aqueous solution. The equilibrium constant value was determined by potentiometric titration using a combination fluoride specific ion electrode system at several ionic strengths and the enthalpy of the association measured by means of calorimetric titration. To the authors' knowledge, there has been only 1 previous investigation of this system, that being the conductometric measurements of Robinson and Bates. Their reported value for this equilibrium constant is considerably smaller than that obtained in the present investigation.

Shipman, J. N., S. E. Thompson and C. C. Thompson, Southwest Missouri State University, Springfield, MO 65804. INEXPENSIVE DIGITAL INTERFACE FOR A DOUBLE BEAM SPECTROPHOTOMETER. Digitization and signal averaging of spectroscopic data can lead to improved accuracy and precision compared to recorder and other analog devices. An inexpensive system has been developed to interface a Cary 14 spectrophotometer with an Apple II+ microcomputer. Instrument performance has been tested using commercial photometric standards, aqueous chromate solutions and a series of aromatic-aliphatic hydrocarbon mixtures. The interface components, circuitry, assembler language and BASIC software, and test results will be discussed.

Thompson, C. C., S. E. Thompson and J. N. Shipman, Southwest Missouri State University, Springfield, MO 65804. INDIRECT SPECTROSCOPIC EXAMINATION OF MOLECULAR ASSOCIATIONS. Although some molecular interactions lead to readily observable spectroscopic changes, others occur with no detectable alteration in spectral properties. Techniques have been developed for indirect spectrophotometric studies of molecular associations of the latter class. However, these methods are strongly dependent on measurements of rather small differences in moderately large absorbance values. The digital interface/signal averaging system described in the preceding paper has been used to examine molecular complexes formed by competitive solute-solute interactions. Results for several of these mixtures will be reported.

Mokmin, U., C. Miller, H. R. Pinnick and M. Readnour, Southeast Missouri State University, Cape Girardeau, MO 63701. DETERMINATION OF THE STABILITY CONSTANTS FOR FLUORO COMPLEXES OF COBALT (II) AND ZINC (II). The stability constants of the fluoro complexes of Co^{2+} and Zn^{2+} were obtained by using a fluoride specific ion electrode in conjunction with a microcomputer potentiometric titration system. All measurements were made at 1.0 m ionic strength and 25.0 ± 0.2 C. The value of the stability constant (K_1) for formation of CoF^+ was found to be 4.2 ± 0.4 and the value of K_1 for formation of ZnF^+ was determined to be 5.0 ± 0.4 .

Roy, R. N., J. J. Gibbons, G. Baker, L. Rowe, R. Pogue and T. McGinnis, Department of Chemistry, Drury College, Springfield, MO 65802. THE SYSTEM $\text{Mg}(\text{HCO}_3)_2 + \text{MgCl}_2 + \text{H}_2\text{O}$ at 25°C. APPLICATIONS OF PITZER'S EQUATIONS. Potentials for the cell without liquid junction $\text{Pt}, \text{H}_2 + \text{CO}_2/\text{Mg}(\text{HCO}_3)_2(m_1), \text{MgCl}_2(m_2), \text{CO}_2(m_3)/\text{AgCl}, \text{Ag}$ have been determined over a broad range of solute concentrations (from 0.1 to 5.0 mol kg^{-1}) at

25 C. These results have been used in conjunction with previously available electrochemical cell data to calculate ionization constant values (pK_1 's) of carbonic acid, as well as activity coefficients (γ_{\pm}) of aqueous $(Mg(HCO_3)_2)$ and $MgCl_2$ using the ion-interaction equations of Pitzer for mixed electrolyte systems. In addition, the pure electrolyte parameters $\beta^{(0)}$, $\beta^{(1)}$, and C^{\pm} have been determined, and the binary interaction parameter (θ_{MN}) and ternary interaction parameter (Ψ_{MNX}) have been calculated, and will be compared with the corresponding values obtained from studies of other mixed electrolyte systems.

Conservation

Cook, J. C., Southwest Wastewater Treatment Plant, Springfield, MO 65808. SEASONAL ABUNDANCE AND BIOMASS OF RIFFLE BENTHIC INSECTS IN A WASTEWATER RECEIVING STREAM. Seasonal abundance, diversity and biomass of riffle benthic insects were studied in a losing stream which receives effluent from the Southwest Treatment Plant. A total of 36 genera of aquatic insects were taken in kickscreen and surber samples collected monthly from 1 site above and 3 sites below the plant from March 1981 until March 1982. Although there was little difference in average abundance above and immediately below the plant, both biomass and diversity decreased immediately below the plant. Abundance, biomass and diversity were all substantially higher 6 km below the plant. Diversity and biomass varied seasonally with peaks during late winter to early spring and again during late summer to mid-autumn. In comparison to a survey undertaken during 1964-66, the data indicate improvement in stream quality. The treatment plant was upgraded from secondary to tertiary treatment in 1976.

Pitts, D. E., Southwest Missouri State University, Springfield, MO 65804. NATIVE WARM-SEASON GRASS ESTABLISHMENT USING MINIMUM-TILL SEEDING METHODS. Minimum-till during fall and spring, hand broadcast and clean-till methods were tested for a planting mixture of big bluestem (*Andropogon gerardi*) and Indian grass (*Sorghastrum nutans*) during 1980-81. Roundup herbicide was sprayed on fescue sod prior to seeding in the fall and again before seed germination. Each treatment was replicated 3 times. Stem density per 0.125 m² for big bluestem was significantly greater using the clean-till method than for the other methods, which did not differ significantly from each other. Hand broadcasting resulted in significantly higher stem density per 0.125 m² for Indian grass than for clean-till method, and both of these were significantly better than either of the minimum-till methods.

Environmental Science

Sharp, J. R., Southeast Missouri State University, Cape Girardeau, MO 63701. EFFECTS OF MERCURY ON SURVIVAL AND DEVELOPMENT OF 3 DIFFERENT AGES OF EMBRYOS OF THE FRESHWATER PERCID TELEOST, *ETHEOSTOMA CAERULEUM*. Three-day, 5-day and 7-day old embryos were exposed to aqueous solutions of mercury, as mercuric chloride, throughout the remainder of the embryonic stage and for a posthatch period of 60 days. This was a static renewal bioassay with solutions being replaced every 24 hours. Embryonic parameters measured included the 96-h survival following initiation of exposure, total hatching success, percent of the successfully hatched embryos expressing spinal curvature and total length of first day eleutheroembryos. As a result of the embryonic exposure, there was a progressive increase in survival and hatching success and a decrease in spinal abnormalities as progressively older (non-treated) embryos were exposed. The post-embryonic exposure was used to determine long-term chronic effects of mercury on survival and growth of this species. Decreases in survival and growth were determined for all concentrations tested other than the control.

Lenz, M. and D. Yourtee', University of Missouri, Kansas City, MO 64108. COMPARISON OF NEW LABORATORY AND THEORETICAL CLASSIFICATION SCHEMES FOR RANKING ENVIRONMENTAL TOXICANTS. The need for rapid, inexpensive and accurate tests for biological risk analysis has been necessitated by modern industrial growth. The number of new chemicals being produced annually range from the hundreds to the thousands, and regulatory agencies such as the EPA must depend on reliable tests to evaluate the toxicity of these new compounds. Screening procedures for mutagens, carcinogens and teratogens, as well as the classical acute and chronic tests, have been used to assess newly manufactured products. These tests and recently developed chemical assays from our laboratory will be discussed.

Mills, S. H., A. W. Brush and G. A. Reinhart, Central Missouri State University, Warrensburg, MO 64093. ALTERED INSULATION IN NEUROPATHIC RATS. Immature (358 g) and mature (536 g) rats ($n=30$) have been effectively intoxicated with a metabolite (acetylacetone) of methyl butyl ketone by treatment of the drinking water. Intoxicated rats had body temperatures which were not altered significantly ($p<0.05$) by cold exposure. Oxygen consumption was more variable and apparently higher at temperatures below the lower critical temperature in intoxicated rats compared to normal rats. Tail temperatures of intoxicated rats increased passively during transient heating. Reduced insulation in intoxicated rats may be correlated with hair loss, poor fur maintenance and impaired vasomotion.

Forensic Science

McGinnes, E. A., Jr., School of Forestry, Fisheries and Wildlife, University of Missouri, Columbia, MO 65211. PROBLEMS IN FORENSIC WOOD SCIENCE. The complex structure plus the great natural variability of wood

are frequently causes for both frustration and concern in forensic debates. With the substantial financial rewards in cases where product failure is a factor, it is indeed important to establish where in the chain of events of product manufacture legal responsibility lies. Wood and wood-based materials are no exception to this requirement. As a result of some 15 years of experience we have developed concepts and procedures to follow when wood is suspect. Specific topics discussed are: species identification, grading rules, natural vs. manufacturing defects and merchandising steps. Appropriate laboratory and field techniques are presented.

Geography

Lell, D. I., Southeast Missouri State University, Cape Girardeau, MO 63701. AFGHANISTAN: SEARCH FOR NATIONAL INTEGRITY - 1984. Lying astride historical invasion routes, and a battleground for outsiders, modern Afghanistan that rose in 1747 was a buffer state between Czarist Russia and the British in India until it gained control over external affairs in 1919. Lacking political viability, and lacking a "second" and "third" force, its symbiotic relationship with the Soviet Union led to Soviet military occupation and a worsening of the Afghan economy. What lies ahead for Afghanistan, "russification" or independence?

Roark, M. and W. Florich, Southeast Missouri State University, Cape Girardeau, MO 63701. FRENCH LONG-LOTS IN MISSOURI. Eighteenth century French cultural influences in the mid-Mississippi valley have had little impact on the regional cultures of the area today, except for the long-lot settlement system. The long-lot settlement system of the St. Lawrence River valley was transferred to Missouri and Illinois in the early eighteenth century and then underwent several modifications which reflected the fundamental change of the French settler society from a medieval folk culture to a modern commercial one.

Rhodes, K., Southwest Missouri State University, Springfield, MO 65804. SMALL TOWN AND RURAL POPULATION CHANGE IN SELECTED MISSOURI COUNTIES: 1970-1980. Today, approximately one U.S. resident out of every 6 lives in a nonmetropolitan city or village. This study traces the movements of people within the counties of Taney, Christian, Mississippi, Texas and Mercer for the period 1970 to 1980, and suggests reasons for the resulting changes in population geography.

Geology - Geophysics

Kern, L., Department of Earth Sciences, Southeast Missouri State University, Cape Girardeau, MO 63701. THE INFLUENCE OF FIELD-WORK ON LEARNING IN AN INTRODUCTORY, GEOSCIENCE LABORATORY COURSE. The educational desirability of field work has been long recognized by geoscience educators. However, this belief has been largely based on qualitative impressions. In order to achieve a more quantitative appraisal, 2 sections of the same laboratory course (Earth Science Lab) were taught by the same instructor during the fall of 1982. One class was conducted in the traditional manner—primarily classroom activities utilizing a lab manual; the other was designed with a field-oriented approach. Content topics were identical in the 2 classes. Identical final exams were administered to both groups at the conclusion of the term. Analysis revealed that with regard to *factual learning*, there was no significant difference (at $\alpha = 0.05$) in the performance of the 2 classes. However, with regard to *conceptual learning*, the field-oriented group scored significantly higher (at $\alpha = 0.01$), indicating greatly enhanced conceptual learning with the field-oriented approach.

Westgate, J. W., Department of Geological Sciences, University of Texas at Austin, Austin, TX 78712, **K. Messick and G. Krizanich**, Department of Geography and Geology, Southwest Missouri State University, Springfield, MO 65804. THE PLEISTOCENE PECCARY *MYLOHYUS FOSSILIS* FROM PLUMMER CAVE, DOUGLAS COUNTY, MISSOURI. A nearly complete *Mylohyus* skeleton collected from Plummer Cave displays traits of both coastal plain (*M. fossilis*) and inland (*M. nasutus*) populations of *Mylohyus*. The combined range of variation of these groups is comparable to that of living peccaries. Observed differences appear to be the result of intraspecific regional variation. *M. nasutus* (Leidy 1868) is a junior synonym of *M. fossilis* (Leidy 1860). Reports of *Mylohyus* in Missouri have previously been restricted to Jefferson County, south of St. Louis. That material consists of a partial skeleton and isolated teeth. The Plummer Cave specimen is the first evidence that *Mylohyus* inhabited southern Missouri.

Voss, R. L. and R. D. Hagni, University of Missouri, Rolla, MO 65401. PRELIMINARY OBSERVATIONS ON A CATHODOLUMINESCENT MICROSTRATIGRAPHY FOR THE SPARRY DOLOMITE FROM THE VIBURNUM TREND, SOUTHEAST MISSOURI. One hundred samples of sparry dolomite were collected from all of the mines throughout the Viburnum Trend. Examination of polished thin sections with cathodoluminescence microscopy reveals a systematic pattern of banding resulting from growth zoning within individual dolomite rhombs. The 4 principal bands can be traced, a distance of 45 miles throughout the length of the Trend, as well as east-west across the Trend. Individual bands only a few microns wide can be correlated between samples collected tens of miles apart. The widths of the principal bands, together with dolomite abundance, provide new evidence for entry points and possible directions of flow of the fluids that deposited dolomite.

Hasan, S. E. and B. E. Kusmin, University of Missouri, Kansas City, MO 64110. AN ATTEMPT AT STABILITY EVALUATION OF LIMESTONE MINES IN THE KANSAS CITY AREA. Pennsylvanian age sedimentary rocks crop out over a large area in metropolitan Kansas City. The Bethany Falls limestone, because of its desirable

physical and chemical properties, has been extensively exploited for various uses. This limestone unit, averaging 6-8 meters thick, has been extracted largely by underground mining using the room and pillar method. The mined out spaces have been put to secondary use and currently over 250,000 mi² of underground spaces have been developed for a variety of uses in the Greater Kansas City area. Several factors control the conversion of a mine into secondary space. Of these, geomechanical factors are of great importance because the structural stability of the mined spaces directly depends on these parameters. The paper discusses the relative significance of the geomechanical parameters in development of a numerical rating system for evaluation of stability of limestone mines.

Easson, G. L. and R. C. Laudon, University of Missouri, Rolla, MO 65401. LITHOLOGY AND SEDIMENTOLOGY OF THE GRAYDON SPRINGS CHANNEL, PENNSYLVANIAN OF SOUTHWESTERN MISSOURI. A field and laboratory investigation of the Desmoinesian Graydon Springs channels was conducted in Polk, St. Clair, Cedar, Dade, Greene and Lawrence counties in southwest Missouri. These outcrops occur as linear channel-like features that trend north-south and cut downward into Lower Pennsylvanian, Mississippian and Ordovician age rocks. The member generally occurs as a fining upward sequence that is composed of a lower conglomerate unit and an upper mature to super mature quartz arenite unit. The presence of fining upward sequences, coupled with paleocurrent data, overall geologic framework, cumulative frequency distribution curves and member geometry suggest that the Graydon Springs channels represent point bar sequences that were deposited by a meandering stream that flowed generally southward across western Missouri during Desmoinesian time.

Cocke, J. M. and M. Mountcastle, Central Missouri State University, Warrensburg, MO 64093. A NEW GENUS OF UPPER PENNSYLVANIAN MISSOURIAN TABULATE CORALS. Specimens here described most closely resemble *Michelinia* (Subfamily Michiliniinae of Family Favositidae) in corallum form, presence of incomplete tabulae in most corallites and distribution of mural pores. They differ from that genus in lacking tabulae in the lower $\frac{3}{4}$ of most corallites where dense skeletal calcite fills the inner space of the corallite. The tabulae are rare, incomplete and convex upward near the calices. Mural pores are sparse throughout each corallite. The corals have been collected in transitional beds between the Upper Pennsylvanian, Missourian Nellie Bly, and Dewey Formations in Washington County, Oklahoma and from the Nellie Bly of Tulsa County.

Fraunfelder, G. and J. R. Jennings, Southern Illinois University, Carbondale, IL 62901. ENVIRONMENTS OF DEPOSITION OF THE LOWER CHESTERIAN AUX VASES-RENAULT SEQUENCE IN SOUTHEASTERN MISSOURI AND SOUTHWESTERN ILLINOIS. At the Aux Vases type section in southeastern Missouri and to the Northeast in Randolph and Monroe counties, IL, the Aux Vases is characterized by sandstone units which are largely massive, whether thick or relatively thin, that appear to be bioturbated (units that lack bedding and sedimentary structures, for the most part). Also in Randolph and Monroe counties, IL, there seems to be a north-south trend along which the middle and upper sandstones in the Aux Vases and the lower sandstones in the Renault at its type section contain well-developed vertical burrows characteristic of the *Skolithos* facies of the littoral to tidal flat or intertidal zone. These vertically burrowed sandstones are overlain, in most places, by shales and limestones bearing marine fossils indicative of shallow shelf deposition and a transgressive sequence. The vertically burrowed beds themselves are indicative of nearshore deposition; and therefore, of the position of the shoreline during lower Chesterian times.

Tibbs, N. H., Department of Earth Sciences, Southeast Missouri State University, Cape Girardeau, MO 63701. USE OF A COMPETITIVE GAME TO ILLUSTRATE MINERAL EXPLORATION IN PHYSICAL GEOLOGY. A competitive game has proven popular with Physical Geology students as a method of teaching concepts of mineral exploration. In a mineral play in an imaginary country, students with varying financing individually bid for leases and explore for ore deposits. Successful explorationists construct cross sections and maps, extrapolate geology to untested ground, develop exploration models and budgets, cope with unexpected operating problems, form limited partnerships and negotiate with financiers. Competition encourages individual effort and achievement and discourages the usual unauthorized cooperation among students assigned a major problem. The principal disadvantage of the game is the amount of time required of the instructor. For best results, other class activities should be avoided during the game.

Brandom, R. T. and R. D. Hagni, University of Missouri, Rolla, MO 65401. ORE MICROSCOPIC STUDY OF THE PRECAMBRIAN BOSS-BIXBY COPPER-IRON DEPOSIT, SOUTHEAST MISSOURI. A preliminary ore microscopic study has been conducted on ores of the Boss-Bixby copper-iron deposit. The hypogene ore minerals include magnetite, hematite, chalcopyrite, bornite, ilmenite, sphalerite, pyrite and carrollite (Co₂CuS₄). Minor oxidation detected in most polished sections include martite, anatase, rutile and covellite. Martitization is most intense near the Precambrian surface. Textural evidence suggests that 2 stages of iron and iron-titanium oxide deposition occurred prior to copper-iron sulfide introduction. Information on the timing of oxidation events and bornite-chalcopyrite mineralization will be obtained by further microscopic studies. Further work will include electron microprobe analyses of the iron and iron-titanium oxides for geothermometry.

Sumner, H. S., Shell Oil Company, New Orleans, LA 70124. DELTAIC SEDIMENTATION IN UPPER CHEROKEE-LOWER MARMATON CYCLOTHEMS OF NORTH-CENTRAL MISSOURI. Prodelta, distributary channel and interdistributary facies comprise the constructive deltaic sequences present in Upper Cherokee-Lower Marmaton-age cyclothems of north-central Missouri. The notable lack of delta front and distributary mouth bar facies is attributed to the low-energy coastal conditions that are felt to have existed in the shallow Pennsylvanian epicontinental seas. Such conditions would have favored the formation of small scale, high-constructive, "muddy,"

Plaquemines ("Birdsfoot") type deltas. These deltas, fed by small northeast-southwest flowing streams carrying a fine-grained sediment load, would have formed coalescing delta complexes of vast areal extent as they prograded across northern Missouri from the northeast to the southwest. The deltaic construction and basin-filling episode in each cyclothem would have occurred rapidly during the initial stage of interglacial warming when fluvial discharge, due to glacial ablation, was at a maximum.

Gerontology

Flax, N., University of Missouri, St. Louis, MO 63121. THE EFFECTS OF ASSERTIVENESS TRAINING ON THE BEHAVIOR OF OLDER MEN. This paper will deal with the impact of a youth-oriented society on older men and how assertiveness training can help them cope better. Many older men feel inadequate in a society which stresses youth and devalues older people. Men are often unable to express themselves. The healthy individual is one who can express emotions and feelings. Men are products of a society which makes them insensitive and often they develop a feeling of impotency, leaving them aggressive or non-assertive. Perhaps the most important single influential factor in creating this feeling of inadequacy in older men is the stereotyping created by the mass media. The media often leaves men feeling inadequate, confused and frustrated. I will present the impact of assertiveness training techniques on older men. Behavioral changes resulted from assertiveness training and helped in modifying relationships and self-esteem. Behavioral changes of non-assertive men took place through training and positive peer reinforcement.

Herpetology

Krohmer, R. W., St. Louis University, St. Louis, MO 63103. EFFECT OF GONADOTROPINS ON IMMATURES OF THE COMMON WATER SNAKE (*NERODIA SIPEDON*). Eighty-five, captive born, male water snakes were placed into 5 groups and given injections of 10 µg or 25 µg, FSH or LH daily. Control animals received 10 µl saline daily. Animals were sacrificed at 3, 7, 14, 21 and 28 days after initial injection. The testis and kidneys were removed, weighed and examined histologically. Testis mass and seminiferous tubule diameter increased in response to both gonadotropins. Kidney mass increased slightly while tubule diameter of the sexual segment of the kidney hypertrophied and developed sexual granules in response to both gonadotropins. Testis development and the apparent release of testosterone, preceded hypertrophy of the sexual segment of the kidney.

Westphale, C. and N. Aspinwall, St. Louis University, St. Louis, MO 63108. GENE DUPLICATION AND ONTOGENETIC VARIATION IN THE LEAST BROOK LAMPREY, *Lampetra aepyptera* (Abbott). A population of the least brook lamprey was examined by horizontal starch gel electrophoresis for gene duplication and ontogenetic variation. Of 17 enzymes analyzed, 3 were found to have been duplicated in the course of evolution. Ontogenetic variation was shown in glucosylphosphate isomerase.

Scheibe, J. S., Southeast Missouri State University, Cape Girardeau, MO 63701. PATTERNS OF RICHNESS AND STRUCTURE AMONG SOME SOUTHWESTERN LIZARD COMMUNITIES. Habitat use data and morphological data were collected for lizards at 20 southwestern study sites. Hypotheses concerning possible variables responsible for patterns of richness and structure were tested. Mean July temperature, mean January temperature and precipitation were good predictors of lizard species richness. A canonical correlation analysis revealed a significant relationship between lizard morphology and habitat use; small slender lizards were found in warm open habitats while large bulky lizards were found in cooler arboreal situations. No significant relationships were detected between community size and parameters of niche overlap or species packing. Likewise, comparisons of observed communities with randomly generated null communities provided no evidence for a limiting similarity in ecological or morphological space.

Matter, J. M. and R. D. Aldridge, St. Louis University, St. Louis, MO 63103. FEEDING AND REPRODUCTIVE CORRELATES IN THE SOUTHEASTERN CROWNED SNAKE, *TANTILLA CORONATA*. Digestive tracts of 73 female and 137 male *T. coronata* were examined for food contents. Snakes were collected near Aiken, South Carolina, from 1979-80 and 1982-83. The active season extends from mid-May through September. All mature female snakes from May through July (n=46) were found to feed. This period corresponds to the time of vitellogenesis and oviposition. From August to the end of the active season 67% of females had fed. Males showed little seasonal variation in feeding frequency—May (100%, n=2), June (88%, n=35), July (91%, n=59), August (68%, n=31) and September (78%, n=9). These monthly feeding frequencies were not significantly different.

Aldridge, R., St. Louis University, St. Louis, MO 63103. COMPARISONS OF RELATIVE CLUTCH MASS IN SNAKES: ERRORS IN DETERMINATION OF MASS. Relative clutch mass has been defined as the total offspring mass/female total mass, including clutch mass (Seigel and Fitch, 1984 Oecologia). These authors compared the clutch mass of oviparous snakes at oviposition with live bearing snakes at birth. I have found that in the watersnake, *Nerodia sipedon*, the mass of embryos increase approximately 3X during development with the total change in weight being due to increased water content of the developing embryos. Thus, the comparison of the mass of young at birth with the mass of eggs at oviposition is a grossly inaccurate measure of relative clutch mass.

Oncology

McCune, R. A., R. W. Oxenhandler, A. Subtelny, and H. W. Tyrer, Cancer Research Center, Columbia, MO. SOME PARAMETERS AFFECTING THE PRECISION OF FLOW CYTOMETRIC MEASUREMENTS. The quantitative precision of fluorescence measurements on the flow cytometer can be dependent on the dead volume of the sample introduction system, the number of cells sampled per distribution and the flow rate of the cells. The magnitude of these effects is related to the type of cells being analyzed, the fluorochrome used and the sample preparation procedure. Precision on the order of 1% coefficient of variation can be achieved for replicate determinations of the fluorescence distribution in a single cell sample.

Losty, T., M. J. Lopez, and H. W. Tyrer, Ellis Fischel State Cancer Center, Columbia, MO. MONITORING ANTITUMOR IMMUNITY WITH THE LEUKOCYTE ADHERENCE INHIBITION ASSAY (LAI). Seventeen tumor-free control patients and 55 tumor-bearing patients were tested for tumor immunity using the Leukocyte Adherence Inhibition Assay. The ability of the assay to demonstrate absence of tumor in tumor-free control patients was 85%. In tumor-bearing patients tested with antigens unrelated to the patient's tumor type, the specificity was 84%. The ability to detect tumor in cancer patients was 62%. The suboptimal detection level may be due in part to some of the patients being immunocompromised as a result of large tumor burden or to suboptimal nutritional status. Further, varying degrees of heterogeneity may exist for tumor antigens present in different tumor bearers, even though the tumors are of similar histological type. The authors conclude that the LAI assay detects tumor presence and has potential value in a clinical setting.

Kapoor, A., W. Kraybill and B. Allen, University of Missouri, Ellis Fischel State Cancer Center, Columbia, MO. INCIDENCE OF HEART DISEASE AND ATHEROSCLEROSIS IN LUNG CANCER PATIENTS. This retrospective study of autopsied patients with all lung cancers was undertaken to study the incidence of heart disease and atherosclerosis. All patients with lung cancer autopsied between 1964 and 1983 at Ellis Fischel State Cancer Center were included in the study. There were 64 patients, 32 with oat cell cancer, 22 with epidermoid cancer, 5 with adenocarcinoma and 5 with large cell cancer. Eighty-six percent of the patients had history of smoking. Electrocardiograms were abnormal in 80% of the patients, 25% of the patients had myocardial infarction by EKG, 51.6% had moderate to severe coronary artery calcification and 57.8% had moderate to severe peripheral vascular disease. Only 7.8% had history of angina. There was absence of coronary artery disease in patients who denied smoking history. More than 50% of patients with lung cancer have significant heart disease and their disease is not detected antemortum. Proper identification of these patients should include cardiac evaluation noninvasively. This study supports the concept that smoking causes lung cancer, coronary artery disease and atherosclerosis.

Reynolds, R., A. Khojasteh, A. Garcia, N. Anson, J. Walter, M. Doyle, and J. McEntire, Ellis Fischel State Cancer Center and Cancer Research Center, Columbia, MO. SPECULATIONS ON VITAMIN C IN CANCER MODULATION. Although others have not been able to reproduce the preservation of life of cancer patients described a decade ago by Cameron and Pauling, epidemiologic and laboratory evidence suggests that ascorbic acid or one of its derivatives may have significant properties that are instrumental in cancer modulation and prevention. Theories of action include electron transfer, enzyme reduction, amino acid metabolism, hormonal regulation and hydrogen ion transport but not antiscorbutic activity.

Srivastava, O. P., W. G. Kraybill, and H. W. Tyrer, Ellis Fischel State Cancer Center and Cancer Research Center, Columbia, MO. DETERMINATION OF TUMOR ANTIGEN BINDING CELLS IN BREAST CANCER PATIENTS USING FLOW-CYTOMETRY. An antigen binding cell assay has been developed which uses the reaction of mononuclear cells from patients with breast cancer to antigens derived from breast tumor tissue. Tumor associated antigens were extracted from tumor tissues with 3M KCl. Mononuclear cells were prepared from peripheral blood by Ficoll-Paque centrifugation. Autologous erythrocytes were conjugated to tumor antigens with CrCl₃. The mononuclear cells were incubated with the antigen-linked autologous erythrocytes and the frequency of rosette forming cell (RFC) response was measured using FCM. Experimental controls used erythrocytes linked with either human serum albumin or nonbreast cancer tumor antigens. Among healthy donors, only 2 of 30 (7%) showed positive RFC responses. A high frequency of positive RFC responses (17 of 27; 63%) were observed among breast cancer patients. The RFC responses in cancer patients were mediated primarily by monocytes. The potential value of this assay as a tumor marker needs further investigation.

Srivastava, O. P., W. G. Kraybill, and H. W. Tyrer, Ellis Fischel State Cancer Center and Cancer Research Center, Columbia, MO. REACTIVITY OF BREAST CANCER PATIENTS MONONUCLEAR CELLS TO PARTIALLY PURIFIED BREAST TUMOR ANTIGENS IN THE ANTIGEN BINDING CELL ASSAY USING FLOW-CYTOMETRY. Breast tumor associated antigens were partially purified by TCA solubilization of proteins present in the 3M KCl extract of breast tumor tissues. On SDS-PAGE, only 4 proteins were observed in the TCA solubilized fraction compared to about 40 proteins in the 3M KCl extract. When the TCA solubilized proteins were used in the ABC assay, a higher frequency of positive rosette forming cell (RFC) responses among breast cancer patients (8 of 12; 66.6%) than in healthy donors (2 of 11; 18%) was observed. The RFC responses in cancer patients were primarily mediated by monocytes. The proteins of the TCA solubilized fractions were further purified by gel-filtration methods and tested for their reactivity by the ABC assay. Among the purified proteins, the proteins with molecular weights of 6000 and 40,000 daltons showed positive RFC responses on reaction with the mononuclear cells of cancer patients. These proteins may have potential as breast tumor markers.

Tyrer, H. W., A. Subtelny, J. Miramonti, and J. Johanson, Cancer Research Center, Columbia, MO. CELL DEPOSITION SYSTEM. The Cell Deposition System (CDS) has been constructed and is presently under

evaluation. The CDS obtains its cell data from a flow cytometry opto-electronics head, which has been interfaced to a computer. The computer performs the cell-by-cell data acquisition, data analysis, data storage, real-time image display, on-line storage and individual cell sorting functions. As such, the CDS is implemented by writing the appropriate interrupt service routine. The computer, furthermore, generates the sort word required to place the cell on the prescribed position on the microscope slide and sorts it to that location. The microscope slide is analyzed by a computer-controlled microscope, since the microscope "knows" the position of each cell on the slide. Thus, the flow cytometric data and the microscope data for each cell are correlated for cytochemical and visual parameters. Furthermore, the microscope data for each cell can include a pointer to a second file containing digitized cell data for pattern recognition.

Physics

Kapoor, Y. M., Lincoln University, Jefferson City, MO 65101. COLOR CENTERS IN BARIUM SULFIDE. Color centers produced in single crystals of barium sulfide by additive coloration were studied. Optical absorption and luminescence measurements were made. The main emphasis was on luminescence spectra. A broad F band was observed in optical absorption with 3 partially resolved peaks at 1.70, 2.33 and 2.75 eV. This band was found to be due to transition of a single center. Assuming an $S^2 \rightarrow Sp$ type transition, a good fit to experimental band was obtained based on 1P_1 - orbital triplet excited state being split by the John Teller interaction, primarily the E_g -modes and being perturbed by an 1S_0 excited state coupled by T_{1u} modes. A luminescence band corresponding to 3 peaks in absorption band was found at 1.08 eV. The excitation spectra did not match the absorption band. Calculations for the absorption and luminescence bands were done using 9 dimensional Monte Carlo integration. A detailed study of the multidimensional potential energy surfaces showed that no radiative transitions were possible. The luminescence band should be probably due to some unknown impurity and not the F-center.

Tansil, J. E., Southeast Missouri State University, Cape Girardeau, MO 63701. SOLAR RADIATION IN SOUTHEAST MISSOURI. The daily solar radiation on a horizontal surface has been measured in Cape Girardeau, Mo., since October 1980. Yearly averages of the daily insolation have been found to vary by $\pm 3\%$ with a 3-year mean value of 14.3 ± 0.4 MJ/m². Monthly averages of the daily insolation and clearness index have been computed and are compared to the long-term values measured at nearby locations as given in the National Climatic Center SOLDAY study. It has been found that on a monthly basis the geographical variation of solar radiation is minor except for a 10% reduction at the Cape Girardeau location during the summertime months. Some possible reasons for this anomaly will be discussed.

Anderson, R., University of Missouri, Rolla, MO 65401. FABRY-PEROT INTERFEROMETERS RESPONSE TO SHORT LIGHT PULSES. The response of a Fabry-Perot interferometer will be discussed in terms of a long coherent light pulse, a short coherent light pulse and series of short coherent pulses. Some interesting inferences are drawn on the use of the Fabry-Perot in these situations and in the analysis of the fringe patterns.

Rutledge, H. D., Southeast Missouri State University, Cape Girardeau, MO 63701. THE PHYSICS OF UFO PHENOMENA USED FOR DIDACTIC PURPOSES. The multifaceted UFO phenomenon provides many new examples of the application of physics that can be used for instruction in physics. This paper related to such areas of physics as dynamics of motion, optics, photography, plasmas, solid state, electromagnetics and propulsion. Evaluation of mundane explanations are given for some of the phenomena such as atmospheric plasmas resulting from lightning or earthquake fault stress, such as light flashes produced by the impingement of antimatter upon the atmosphere from space, such as propulsion by antigravitic modes, including translocation to other points in the universe (tunneling through space-time). The author observed most of the examples in southeast Missouri during a 7 year field study called Project Identification.

Hurley, A., and M. Stacey, St. Louis University, St. Louis, MO 63103. A 2-CHANNEL DIGITAL OSCILLOSCOPE USING THE APPLE II. We will describe simple, inexpensive circuitry and computer programs needed to acquire and digitize data on 2 or more channels at the same time. The analog signals are multiplexed, digitized and then read into the computer through a Motorola MC6820 Peripheral Interface Adapter. The data can be plotted on the monitor to form an image similar to an oscilloscope trace.

Benofoy, L. P., St. Louis University, St. Louis, MO 63103. NONINTEGER DIMENSIONAL OBJECTS (FRACTALS) AND PHYSICS. The existence of noninteger dimensional objects will be suggested through the detailed discussion of an historically interesting geometrical object: it will be shown that this object has some properties which do not fit our ordinary notions regarding integer dimensional objects. Then the definition of the so-called fractal dimension will be presented. It will be shown that for standard geometrical objects the fractal dimension is an integer, while for other objects (called fractals) it is not. Finally some potential applications of fractals to physical situations will be suggested.

Gerson, R., University of Missouri, Rolla, MO 65401. USE OF THE RADIO SHACK TRS 80 COLOR MICROCOMPUTER IN A GENERAL PHYSICS LABORATORY. Large student loads, economic limitations and the constraint of a 2-hour laboratory period are some of the factors to be considered if a single microcomputer is to be used in a General Physics laboratory. The computer can, however, serve both as a motivational and an educational tool. A TRS 80 Color Microcomputer has been used for linear least-squares analysis of laboratory data in a short program with graphical output. While this program represents minimal use of the computer's functions, it

serves as an introduction to the numerical processing of physical data. The program, and the reasons for its structure and functions, will be discussed.

Babcock, D. V., Lincoln University, Jefferson City, MO 65101. ON A TEACHING TECHNIQUE REGARDING THE HEAT OF VAPORIZATION RELEASED DURING A RAINSTORM. Appropriate to high school and college students, a comparison will be made relating two items, viz (a) the process during which the atmosphere is cooled, thereby triggering release of energy by water vapor to the surrounding air and thereby *tending* to warm that air and (b) the process by which a cold blast of air into a house triggers the furnace to come on, thereby *tending* to warm the house. Typical amounts of energy released during a rainstorm will be compared with energy releases by atomic bombs. Also some attention will be given to the "tend to" idea and its implicit denial of the "exclusive - OR" where it is applicable.

Sparlin, D. M., University of Missouri, Rolla, MO 65401. DATA ACQUISITION AND EXPERIMENT CONTROL—ADVANCED LABORATORY 1984. A simple interface is described and demonstrated for use in laboratory experiments for juniors and seniors. Eight, eight bit, analogue to digital inputs are continuously converted and made available at successive memory locations. Two 8-bit digital to analogue converters provide signals from 0 to 2.55 volts output. The use of memory mapping provides PEEK and POKE access for simplified programming.

Hultsch, R. A., University of Missouri, Columbia, MO 65211. PHYSICS DEMONSTRATIONS. 1. An object whose 3 principal moments of inertia are different, $I_1 > I_2 > I_3$, rotates unstably when started about the intermediate axis I_2 . 2. A thick, very low resistance metal ring, as a secondary coil of a transformer, feels a force greater than its weight and also is heated considerably. These effects depend on the relative phase of the primary coil magnetic field and the induced ring current being not 90° . The impedance of the ring is as inductive as resistive. We will demonstrate how the ring current of the order of 1000 Amperes can be easily measured. Detailed explanations of both of these demonstrations will be distributed.

Science Education

Delaware, D. L. and D. L. Hanks, Northeast Missouri State University, Kirksville, MO 63501. SCREENING PROGRAM FOR ENTERING FRESHMAN SCIENCE MAJORS AT NORTHEAST MISSOURI STATE UNIVERSITY. Performance levels of entering NMSU freshman science majors in required mathematics and chemistry courses have been cause for increasing concern during recent years. It is our feeling that many high school graduates are enrolling in college science programs, with mathematic deficiencies, thus assuring the student of difficulties in chemistry courses. A testing program was developed to screen incoming freshman science majors and to give academic advisement regarding freshman courses. The screening and advising program will be discussed, as well as some preliminary results of testing.

Hoggard, F., L. Sheets and R. Sheets, Southwest Missouri State University, Springfield, MO 65804. USING GAMES AS A STRATEGY TO TEACH SCIENCE CONCEPTS. As civilization evolves to a higher and higher technological state, the ability to use models and other abstractions in science teaching becomes more and more necessary. This paper presents the technique of using Paul Emfest's bead games to teach the important concepts of random walk, equilibrium, growth and catastrophe. Various ways of playing the games using a simple matrix and dice, playing by computer and by allowing the computer to play the game automatically, will be demonstrated.

Science, Technology & Society

Valentine, D., Senate Research Staff, Jefferson City, MO 65101, and **L. J. Peery**, Senate Research Staff and Central Methodist College, Fayette, MO 65248. TECHNOLOGY AND UTILITY REGULATION. A review of the origin and history of utility regulation and its relation to technology developments will be presented. The current regulatory issues will be discussed and the near term outlook examined. Various regulatory reform measures are analyzed as well as potential technological advances.

Peery, L. J., Senate Research Staff, Jefferson City, MO 65101, and Central Methodist College, Fayette, MO 65248, and **D. Valentine**, Senate Research Staff. STATE GOVERNMENT AND HIGH TECHNOLOGY INDUSTRY. A review of the historical role of state government in economic and technological development is presented. The potential to develop high technology industry in Missouri is also examined. In addition, various government initiatives are considered to foster the development of "high technology" firms.

Drennan, O. J., Northeast Missouri State University, Kirksville, MO 63501. THE CONSEQUENCES OF CHANGES IN CONTEMPORARY SCIENCE. The size of science—in terms of manpower, money and natural resources used—has been growing exponentially for several centuries. Such growth must decrease at some point in time. This analysis indicates contemporary science is experiencing this necessary alteration in growth with significant effects for science itself and for society as a whole.

COLLEGIATE DIVISION

Biological Sciences

Wendy D. Weger and W. J. Tietjen, Lindenwood College, St. Charles, MO 63301. BEHAVIORAL ECOLOGY AND SPATIAL DISTRIBUTIONS IN THE BOWL AND DOILY SPIDER *FRONTINELLA PYRAMITELA*. Most spiders are solitary and show a random or dispersed distribution. However, *F. pyramitela* exhibits a clumped distribution under natural conditions suggesting either an interaction among animals or with features of the habitat. Experiments indicated that prey availability and plant structure were of little significance in explaining the distribution. Under laboratory conditions, *F. pyramitela* also exhibits a clumped distribution and shows little preference in the choice of web sites as related to the varying complexity of artificial substrata. These data suggest that *F. pyramitela* may be attracted to each other and are thus socially interacting.

Christine L. Jordan, Central Missouri State University, Warrensburg, MO 64093. KARYOTYPE AND NOR STUDIES OF TWO SPECIES OF TRIODOPSIS (Gastropoda; Polygyridae). *Triodopsis albolabris* (Say) and *T. fosteri* (Baker) have a diploid number of 58 chromosomes in embryonic cells. The lengths of chromosomes of both species are overlapping. Statistical analysis of the karyotype of *T. albolabris* will be discussed. The Nucleolar Organizer Regions (NOR) when stained with AgNO₃ point to differences in the 2 species. *T. albolabris* has 4 NOR's on 2 pairs of chromosomes and *T. fosteri* has 2 NOR's on 1 pair of chromosomes. It is therefore hypothesized that a duplication followed by translocation of the additional NOR's has occurred during the evolution of *T. albolabris*. The variation in numbers of NOR's in the 2 species will be discussed.

Robin Merriott, Central Missouri State University, Warrensburg, MO 64093. FEEDING BEHAVIOR AND SURVIVORSHIP STUDIES OF *CHAETOGASTER LIMNAEI* (ANNELIDA; OLIGOCHAETA). *Chaetogaster limnaei* is a symbiont of the freshwater snail *Helisoma*. Experiments on its feeding behavior indicated that protozoans could be a possible source of food. Survivorship studies of isolated *C. limnaei* were conducted in the presence and absence of protozoans (Paramecium, Chilomonas) in the culture medium. The survivorship of *C. limnaei* was significantly prolonged by the protozoans as compared to the controls. Current studies of the survivorship of these worms in an algae/diatom/protozoan culture will be reported and discussed.

Jon Rhodes, Southeast Missouri State University, Cape Girardeau, MO 63701. THE EFFECT OF MERCURY ON OSMO- AND CHLORIDE ION REGULATION OF THE LONGEAR SUNFISH, *LEPOMIS MEGALOTIS*. Adult longear sunfish were exposed for 12-d to 40 ppb Hg + 2 in conditioned tap water to determine if pre-exposure to a sublethal mercury concentration would affect plasma osmolality and chloride ion level, following transfer to a more hypo-osmotically stressful environment (distilled water). Control fish were treated in the same manner but without exposure to mercury. Total plasma osmolality and chloride ion levels were determined for control and Hg + 2 exposed fish at the time of transfer and following 12-d exposure to distilled water. Blood was collected from the caudal artery in heparinized capillary tubes, centrifuged and plasma parameters were measured using a vapor pressure osmometer and chloridometer. All data were analyzed by standard ANOVA procedures with *a priori* linear contrasts. For both parameters, fish treated with mercury had significantly lower values than controls, suggesting that sublethal mercury intoxication may affect the physiological capacity of these fish in maintaining normal osmoregulatory homeostasis.

Susan K. Brauer, Central Missouri State University, Warrensburg, MO 64093. THE RESPONSE OF DIPODOMYS SPECTABILIS TO OLFACTORY, VISUAL AND COMBINED VISUAL AND OLFACTORY CUES FROM *ELAPHE OBSOLETA*. The objective of this experiment was to test the response of the bannertail kangaroo rat (*Dipodomys spectabilis*) to a black snake (*Elaphe obsoleta*), a potential predator. Twelve kangaroo rats (6 males and 6 females) were exposed to olfactory, visual and a combination of visual and olfactory cues from the black snake. Rats were scored during 10 minute trials for the number of alert postures, vertical jumps, sand kicks, sand baths, recoils and the amount of time spent in the half of the arena containing the stimulus. Males differed from females in the amount of sand kicks, alert postures and vertical jumps, and both sexes performed significantly more jumps, alert postures and recoils in the presence of a combination of visual and olfactory stimuli. Therefore, olfactory signals from a potential predator are more effective in causing a response in kangaroo rats when they are presented in the visual presence of the snake.

Terry L. Henson, Southeast Missouri State University, Cape Girardeau, MO 63701. MEDIA PHOSPHATE AND MYCELIAL PHOSPHORUS CONTENT OF THE FUNGUS, *Schizophyllum commune*. The relationship between media phosphate concentration and total mycelial phosphorus has been studied in the wood-rotting basidiomycete, *Schizophyllum commune*. Available phosphorus at minimal medium concentration (phosphate concentrations below 9.12 mM) is the limiting factor in mycelial growth. Total mycelial phosphorus of 4-day old colonies grown on

minimal medium was not significantly different from those grown on 10 μM Pi. Colonies maintained on minimal medium for 6, 7 and 8 days, however, showed a slight decrease from the phosphate levels of 4-day colonies. A significant increase is seen in total mycelial phosphorus in colonies aged 6, 7 and 8 days on 10 μM Pi medium. Upon starvation, *Schizophyllum* maintains a minimum level of phosphorus while there is an increased affinity for phosphorus in colonies grown on phosphate deficient media.

Carol Cummiskey, Barbara Popovitch, D. M. Grev and J. Maruniak, Columbia College, Columbia, MO 65216. CIRCADIAN RHYTHM OBSERVATIONS. Alteration of normal light/dark cycles is 1 method of studying circadian rhythms. This 8-week study involved 20 sexually mature hamsters divided into 4 groups. One group existed with a light/dark cycle of 6/18 hours and the other 3 groups had a light/dark cycle of 18/6 hours. Of this last set; 1 group was castrated at 4 weeks, 1 group was castrated then received an implant of hormone capsules at 4 weeks and 1 group was not altered. Details and resultant data will be presented.

Kelli Kunkel, Jack Behle and Jim Jackson, Missouri Southern State College, Joplin, MO 64801. A LINEAR REGRESSION ANALYSIS RELATING CLIMATIC FACTORS AND HERD DATA TO BUTTERFAT PRODUCTION IN JERSEYS. This is a 2.5-year study concerning the effects of climatic conditions on butterfat production in Jersey cows. A Linear Regression Analysis computer program was derived to relate the weather data which includes: temperature range, minimum and maximum; rain fall; snow depth; air pressure range, minimum and maximum; wind maximum; humidity range, minimum and maximum; and herd data which includes: pounds of milk, percentage of fat, age of cow, days in milk, lactation number and herd difference in fat. The herd data was collected on a monthly basis through the Dairy Herd Improvement Association. Weather information was obtained through N.O.A.A. The results included: 48% of the variation in fat production as being explained by all the data variables, 3% explained by just weather data, 9.5% explained by weather data on the bottom 16% of animals, 1.8% explained by weather on top 16% and 3.4% explained on the top 6% of producing cows.

Jill Prindiville, University of Missouri, Columbia, MO 65211. COMPUTERIZED INVENTORY AND RETRIEVAL SYSTEMS FOR LIVING PLANT COLLECTIONS. Computers are being used to store, sort and retrieve mountains of data in whatever form the user chooses. Considering all the collected, yet not readily accessible, data of the Woodland and Floral Garden adjacent to our Agriculture building, it seemed only logical to write a computer program that would store such data for later use. The data base consists of the scientific name, location and performance of the plant as well as 27 other categories. This program was written using the DBASE II Management System on an IBM PC. It provides immediate information on specific plants or groups of plants located in the garden and is designed to be used by teachers and students with no computer background. With minor changes, this program has versatile adaption implications for other horticultural exhibits or research areas.

Chemistry & Geology

Judy A. Maune and R. Kent Murmann, University of Missouri, Columbia, MO 65201. PHOTO-CHEMICALLY GENERATED CHARGE TRANSFER COMPLEXES OF $[\text{Os}(\text{en})_2\text{O}_2]^{2+}$. The association of Fe^{2+} with $[\text{Os}(\text{en})_2\text{O}_2]^{2+}$ has been studied spectrally in a group of methanol-water and related mixed solvents and the solvent effect on the stability is very large. Two types of crystals have been isolated and their composition established. A similar, deeply blue colored species is generated when light activates a solution of $[\text{W}(\text{CN})_8]^{4-}$ and $[\text{Os}(\text{en})_2\text{O}_2]^+$. Studies related to the mode of formation, composition and structure of these products will be presented. It is concluded that the reducing agent reversibly associates with the oxygen of the trans-Os complex and that electron transfer through the bridging oxygen gives rise to the color. The instability of Os(V) in this geometry probably results in the reversible nature of the interaction.

Kurt Wulser and Michael Powers, Central Missouri State University, Warrensburg, MO 64093. Solvent structure has been studied many ways. One of these methods is to observe the effect a solute has on the properties of a solution. Through this, one can get an idea of the interactions occurring. With the use of varying sizes of ligands, a range of ion sizes and strengths was obtained. Results from these experiments will be discussed as well as some theoretical basis for the properties.

Chelmer Barrow, Doug Steinhoff and Dennis M. Grev, Columbia College, Columbia, MO 65201 and **J. Steven Morris and Edward D. Heimann**, University of Missouri Research Reactor Facility, Columbia, MO 65211. CONTAMINATION STUDY IV: TRANSFER OF ELEMENTS ASSOCIATED WITH STAINLESS STEEL NEEDLES TO INSULIN DURING COLLECTION AND ADMINISTRATION. Insulin collection and administration may be a source of elemental contamination at the trace levels. This study used neutron activation analysis to ascertain the amount of sample contamination attributable to the use of stainless steel needles for insulin during collection and administration. Details of the method and resultant data will be presented.

A. L. Whitacre and H. D. Anderson, Stephens College Chemistry Department, Columbia, MO 65215, **J. S. Morris**, University of Missouri Research Reactor, Columbia, MO 65211 and **D. D. Makedani**, Lincoln University, Jefferson City, MO 65101. TOTAL SELENIUM AND SE-75 STUDIES IN CARDIAC AND SKELETAL MUSCLE IN THE RAT. The selenium content of cardiac and skeletal muscle was studied in rats using neutron activation analysis and radioassay procedures. Rats on 2 semi-purified diets differing only in fiber content (1% or 10%) were given an IP injection of Se-75 7 days prior to being sacrificed. Cardiac and skeletal muscle samples were removed and freeze-dried. Extracts were prepared using a high speed tissue homogenizer. Total selenium and

Se-75 determinations were made on both samples and extracts. These data will be compared and discussed in terms of organ requirement and the effect of fiber in the diet.

David Gerdts and J. Steven Morris, Missouri University Research Reactor, Columbia, MO 65211. **SELENIUM AND HUMAN NUTRITION: THE UTILIZATION OF TOENAILS AS A DIETARY MARKER.** Selenium (Se) deficiency has been shown to be implicated in both cancer and cardiovascular disease in humans. The range in dietary Se intake in the United States is thought to be 50-200 μg per day; however, in a growing number of individual cases, the daily intake probably exceeds 200 μg due to routine Se supplementation. At this point there is a legitimate question as to the daily requirement of Se necessary to prevent long-term effects of chronic Se deficiency. It was the purpose of this work to evaluate the toenail as a dietary Se marker. Four experiments will be discussed. In Experiment One, toenail Se concentrations (TSC) were correlated with known geographical extremes in Se availability. In Experiment Two, TSC were correlated to supplementation levels of 0, 50, 100 and $> 100 \mu\text{g}$. In Experiment Three, TSC were determined for 2 subjects over time beginning at the time that a daily 50 μg dietary supplement was introduced into the diet. Finally in Experiment Four, TSC are reported and evaluated with respect to sampling, accuracy and precision.

Greg Salchow and J. Steven Morris, Missouri University Research Reactor, Columbia, MO 65211 and **D. D. Makedani**, Lincoln University, Jefferson City, MO 65101. **THE EFFECT OF DIETARY FIBER AND AGE ON SELENIUM UPTAKE IN THE RAT.** The effect of dietary fiber on selenium (Se) uptake has been studied in the rat at 2 different ages using a Se-75 tracer. In Trial One, weanling rats were placed on either a control or high fiber diet. At the end of the fourth week, the rats were given an IP injection of Se-75 (100 Ci/g) and placed in metabolism cages for 7 days. Feces and urine were collected daily. On day 7, the rats (10 weeks of age) were sacrificed and tissues including blood, heart, skeletal muscle, kidney and liver were collected. Trial Two was done in the same way as Trial One except that the rats were maintained on either the control or high fiber diet from weanling until old age. The rats in Trial Two were sacrificed at 85 weeks. Se-75 data for both diets and trials will be presented and discussed.

A. Herrera-Villegas and H. D. Anderson, Stephens College, Columbia, MO 65215, and **J. S. Morris**, University of Missouri Research Reactor and Chemistry Department, Columbia, MO 65216. Hair samples from 185 volunteer nurses participating in the Nurses' Health Study (NHS) Harvard School of Public Health, are being analyzed via instrumental neutron activation analysis. The research objective was to compare the suitability of the hair matrix versus the toenail matrix as a dietary indicator of selenium. Chronic selenium deficiency is of interest due to its implication in both cancer and cardiovascular disease. The sample matrix required to assess dietary intake must meet 2 criteria: (1) Because of large cohorts (100,000 in the NHS), the sample must be easily obtained by the subject and lend itself to easy storage and handling. (2) The selenium concentration in the sample must correlate with the dietary intake. A second project objective was to collect data on other elements which will also provide for further comparison. In addition to Se, data will be reported on Sr, I, Mg, Cu, V, K, Al, Mn, Cl, Na, Ca and S.

Larry D. Sutton and Dana L. Delaware, Northeast Missouri State University, Kirksville, MO 63501, and **Daniel M. Quinn**, Department of Chemistry, University of Iowa, Iowa City, IA 52242. **CHOLESTEROL ESTERASE-CATALYZED HYDROLYSIS OF WATER-SOLUBLE p-NITROPHENYL ESTERS.** Study of bovine pancreatic cholesterol esterase (CEase)-catalyzed hydrolysis of short acyl chain p-nitrophenyl esters has been initiated. CEase shows a greater specificity for p-nitrophenylbutyrate (PNPB) than for p-nitrophenylacetate (PNPA). The respective K_m and V_{max} values measured at 25 C in 0.05 M tris buffer containing 0.1 M NaCl are: PNPA, $K_m = 2.6\text{mM}$, $V_{max} = 1.26 \times 10^{-5} \text{ M sec}^{-1} (\text{unit enzyme})^{-1}$, 3% v/v CH_3CN ; PNPB, $K_m = .046\text{mM}$, $V_{max} = 1.14 \times 10^{-5} \text{ M sec}^{-1} (\text{unit enzyme})^{-1}$, 5% v/v CH_3CN . Benzenboronic acid, a transition state analog inhibitor of serine proteases, is a parent inhibitor of CEase-catalyzed hydrolysis of PNPB, with $K_i = 7.0 \times 10^{-5}\text{M}$. Taurocholate, which is a physiological activator of CEase, inhibits the hydrolysis of PNPB. The corresponding Dixon plot is biphasic, with a sharp downward break at around the CMC of the lipid, which suggests a catalytically important interaction between the enzyme and taurocholate mommers. These results will be discussed in terms of a possible catalytic mechanism of CEase action.

Robert Carson and J. Steven Morris, Missouri University Research Reactor, Columbia, MO 65211. **MULTI-ELEMENT INAA OF TOENAILS FOR TRACE ELEMENTS OF NUTRITIONAL INTEREST.** The toenails analyzed in this project were collected in the Nurses Health Study (Harvard University). Toenails were chosen because of their ease in collection and preservation. Two irradiations were performed, the first for 30 seconds for determination of Na, Mg, Al, S, Cl, K, Ca, Ti, V, Mn, Cu, Br, Sr and I. The second for 50 hours for the determination of Cd, Zn, Cr, Ag, Cu, Ni, Co, Se, Au, As, Sb, Na, K, Mo, Fe and Br. Some of the subjects have been on dietary supplements of some of these elements, if consistently significant amounts of any of these elements are found in these toenails, it would indicate that toenails could be used as an indicator for dietary intake of that element.

Physics & Engineering & Math

Lynn E. Reynolds, Northeast Missouri State University, Kirksville, MO 63501, and **D. F. R. Mildner**, University of Missouri, Columbia, MO 65211. **THE ANALYSIS OF ELLIPTICALLY SYMMETRIC SMALL-ANGLE SCATTERING DATA.** Inhomogeneities which on the average have an atom density function with rotational

symmetry around some unique axis give rise to elliptically symmetric small angle scattering. The usual analysis involves cuts along the principal axes of the contours which uses only part of the data. A better method is to perform an elliptical average of all the data to obtain a 2-dimensional representation of intensity as a function of a reduced scattering vector. This procedure allows all the familiar forms for circularly averaged small angle scattering data to be used with the derived size parameter having an elliptical dependence. Often asymmetric data for which the eccentricity is close to unity are inadvertently circular averaged, so that the size parameter derived is an average of that parameter in the principal directions.

Mark S. Rutledge and R. F. Freeman, Southeast Missouri State University, Cape Girardeau, MO 63701. DATA ACQUISITION USING MICROCOMPUTER INTERFACING. Experimental data has traditionally been obtained by hardware devices connected to various types of recorders to be analyzed. By interfacing the instruments with a microcomputer, most of the hardware can be replaced with a program, or software, making the system less complicated, easier to set up and allows more freedom to change the system parameters. Experiments were performed to obtain the technique that would be most accurate and most versatile for this simple data acquisition system. Further possibilities will also be discussed.

S. Keleti and X. B. Reed, Jr., University of Missouri, Rolla, MO 65401. COMPUTATION OF TURBULENT FINE STRUCTURE FOR RANDOM SOLUTIONS TO BURGERS' EQUATION. Burgers' equation is an often studied 1-dimensional analog of the Navier-Stokes equation, for which exact random solutions have been obtained at high Reynolds numbers. Numerical evaluation of the closed form solution is reasonably straightforward on a spatial mesh which is sufficiently fine to capture the evolution of the energy-containing part of the turbulence spectrum, and turbulent energy decay and the evolution of the spatial autocorrelations, the velocity histograms and the centered moments of the velocity field through the eighth have already been computed. Information on the evolution of the Taylor microscale, the viscous dissipation spectrum and the inertial spectral transfer, as well as statistical measures of turbulent fine structure, require a much finer spatial mesh, for which numerical evaluation of the exact solutions to the required precision is not straightforward. Algorithms which deal with specific ranges of the variables on a case by case basis have been developed and numerical results of the computations will be presented.

J. T. Temple, Southeast Missouri State University, Cape Girardeau, MO 63701. "99". The number 99 has some unusual characteristics as a modulus. Among these are: the number of solutions to a quadratic equation, the means of finding the residue class and finding numbers with given remainders under its factors.

M. Mehregany, C. W. Tompson and D. F. R. Mildner, University of Missouri, Columbia, MO 65211. A POSITION SENSITIVE DETECTOR FOR A POWDER DIFFRACTOMETER. A 3 counter array of linear position sensitive detectors has been constructed and installed on the neutron powder diffractometer at the University of Missouri Research Reactor. The position of an event is determined by charge division method using digital arithmetic. Proper calibration of the detector will result in a linear relation between the event position and channel number. The data is then rebinned into 0.1 degree increments. The instrument parameters are determined by a least squares refinement to Gaussian fits of Bragg diffraction peaks. Consideration has been given to the corrections necessary due to the characteristics of the detector. The enhancement factor for the position sensitive detector is estimated to be about 40 over a single detector with a step scan. This allows for experiments with better resolution, better statistics and smaller samples and marginal experiments are possible.

F. Baganoff and D. M. Sparlin, University of Missouri, Rolla, MO 65401. SYSTEMATIC ERRORS IN SPECTROMETER MEASUREMENTS. The importance of accurate calibration and positioning of light sources and optical apparatus is demonstrated by the errors introduced into the wavelength determined by a grating spectrometer. Methods of reducing these systematic errors are discussed. The improvements found by applying these methods are then discussed.

T. Sommerer and E. B. Hale, University of Missouri, Rolla, MO 65401. AUGER ANALYSIS OF THE BEHAVIOR OF IMPLANTED NITROGEN UNDER HEAVY WEAR CONDITIONS. A current theory concerning the improved wear properties of implanted steel is that the implant produces a surface hardening effect which is perpetuated by the diffusion of the implant with the wear front. Auger spectroscopy was used to characterize the near surface composition of worn steel. No evidence was found of implant diffusion. In addition, the enhanced wear properties remained well after Auger analysis showed no residual nitrogen.

S. Maupin, D. Simkins, T. Sommerer and D. M. Sparlin, University of Missouri, Rolla, MO 65401. A COMPUTER CONTROLLED FRANCK-HERTZ EXPERIMENT. The traditional Franck Hertz experiment was implemented using an Aim 65 computer for data acquisition. The results are compared to those obtained by a manual method.

A. Bedwell and D. M. Sparlin, University of Missouri, Rolla, MO 65401. AN UNDERGRADUATE STUDY OF THE PHOTOELECTRIC EFFECT. The photoelectric effect was studied using tungsten and mercury light sources, a Leybold potassium photocell, and a monochromator instead of interference filters. A comparison of computer data acquisition to manually obtained data will be presented.

D. Pannone, T. Sommerer and D. M. Sparlin, University of Missouri, Rolla, MO 65401. FABRICATION AND ANALYSIS OF THE PARAMETERS OF PLANAR THIN FILM OPTICAL WAVEGUIDES. Organic thin film waveguides have been deposited onto glass microscope slide substrates. A prism was used to couple He-Ne laser light to the guide. The film index, thickness, and film mode angles were directly measured and the results were correlated with waveguide theory.

Social and Behavioral Sciences

Ellen J. Loomis and Nancy A. Marlin, University of Missouri, Rolla, MO 65401. Department of Psychology, UMR, Rolla, MO 65401. SUGAR PREFERENCES OF RATS EXPOSED TO SUGAR BEGINNING AT DIFFERENT AGES. Previous research in which rats were started on high sugar diets prenatally indicated that there was a preference later in life for the diet on which the rats were reared. The present experiment was designed to investigate if a similar dietary preference would be found when the rats were started on the diets at a later stage in their development. At 16 days of age rat litters with their mothers were started on a continuous diet high in either sucrose, glucose or starch. At Day 21 the rats were individually housed and tested for diet preference between the high sucrose or high glucose diets, on a weekly basis, until Day 77. There was no significant difference due to their early diet exposure throughout the experiment.

M. Masters, E. Loomis and F. Haemmerlie, University of Missouri, Rolla, MO 65401. STRESS AND COPING IN INSTITUTIONALIZED VS NONINSTITUTIONALIZED ELDERLY: A ONE YEAR FOLLOW-UP. A 1-year follow-up assessment examined longitudinally how stress and coping differed among male and female elderly living either in their own homes or in nursing homes. Results showed no significant time differences but generally lower well-being scores and less coping skills among the nursing home elderly. Significant gender differences indicated that females use the coping mechanisms of turning to other activities and engaging in social activities more than males. Results are consistent with previous findings on the dynamics of stress and coping in the aging process.

M. Bowles and F. Haemmerlie, University of Missouri, Rolla, MO 65401. PERSONALITY MEASURES AS A FUNCTION OF STAGE OF MENSTRUATION AMONG COLLEGE FEMALES. Two groups of college women were administered the Moos Menstrual Distress Questionnaire and 2 standard personality tests, the Guilford-Zimmerman Temperament Survey and the Minnesota Multiphasic Personality Inventory. One group was tested in the premenstrual phase of the menstrual cycle (days 20-25) and the other group at the beginning of the cycle (days 5-9). Significant differences or trends obtained on all 3 questionnaires corroborate previous findings of distress and negative personality characteristics associated with the premenstrual phase of the cycle.

A. Abdul-Wakeel, M. Pomeroy and F. Haemmerlie, University of Missouri, Rolla, MO 65401. EVALUATION OF MEN AND WOMEN IN VARIOUS PROFESSIONS AS A FUNCTION OF STATUS AND ATTITUDES. Conditions under which male technical undergraduates are prejudiced against men and women in various professions are examined. College males majoring in either engineering or computer science at the University of Missouri-Rolla evaluated professional articles in 2 feminine and 2 masculine fields. The author's sex and title were manipulated such that each article was authored in 4 ways—by a male with no title, a female with no title, a male with a title and a female with a title. A measure of general attitudes towards women was also taken. Evidence indicated some bias against women regardless of title in 3 of the 4 fields and against males without a title in 1 of the feminine fields. No relationship was found between attitudes toward women and how the articles were evaluated.

Sheila M. Sweeney, Lincoln University, Jefferson City, MO 65101. AN ANALYSIS OF POLITICAL POSITIONS AND ATTITUDES OF MID-MISSOURI VOTERS. This paper will present an analysis of a political science research project. The research is based on a political poll taken to sample the positions and attitudes of Mid-Missouri voters. The paper will point out the result of previous polls and demonstrate an application of the data to the 1984 elections.

Betty Richardson-Mims and W. M. Beneke, Lincoln University, Jefferson City, MO 65101. THE RELATIONSHIP OF SPOUSE SUPPORT TO WEIGHT LOSS DURING A BEHAVIOR MODIFICATION DIETARY PROGRAM. Forty overweight women and their husbands participated in a 12-week behavior modification weight loss program. The women were provided nutrition education and counseling and taught to use behavior modification principles to alter their food habits. Their husbands attended bi-weekly classes in which they learned to use behavioral techniques to support their wife's weight loss efforts. When divided into groups of "high attendance" and "low attendance" husbands, wives of "h-a" husbands posted a significantly greater weight loss.

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