



S.06(76)B

The American Museum of Natural History



1869
THE LIBRARY



Digitized by the Internet Archive
in 2017 with funding from
IMLS LG-70-15-0138-15

THE JOURNAL
OF THE
ALABAMA ACADEMY
OF SCIENCE

— AFFILIATED WITH THE
AMERICAN ASSOCIATION FOR THE
ADVANCEMENT OF SCIENCE

VOLUME 50

JANUARY, 1979

NO. 1

EDITOR:

W. H. Mason, General Biology, Auburn University, Auburn, AL 36830

ARCHIVIST:

R. G. Eaves, Department of History, Auburn University, Auburn AL 36830

EDITORIAL BOARD:

R. T. Gudauskas, Chairman, Department of Botany and Microbiology,
Auburn University, Auburn, AL 36830

E. A. Curl, Department of Botany and Microbiology, Auburn University,
Auburn, AL 36830

W. W. Paulder, Department of Chemistry, University of Alabama, Uni-
versity, AL 35486

ADVISORY BOARD:

W. L. Alford, Auburn University

Walker H. Land, Jr., IBM

Charles Baugh, Univ. South Alabama

H. S. Marks, N.E. St. Jr. Col.

G. F. Brockman, Univ. Ala., B'ham

M. Miller, Univ. South Alabama

R. J. Fornaro, Univ. South Alabama

W. W. Paulder, UA, Tuscaloosa

A. Wayne Lacy, Auburn Univ., Mtgy.

Dan Whitson, Decatur

E. M. Wilson, Univ. South Alabama

The Journal is the official publication of the Alabama Academy of Science, and is indexed in Biological Abstracts, Chemical Abstracts, America: History and Life, and Historical Abstracts

Publication and Subscription Policies

Submission of Manuscripts. Submit all manuscripts and pertinent correspondence to the EDITOR. Each manuscript will receive two simultaneous reviews. For style details, follow Instruction to Authors, *J. Ala. Acad. Sci.* 48:42-43, 1977.

Reprints: Requests for reprints must be addressed to authors.

Subscriptions and Journal Exchanges: Address all correspondence to the CHAIRMAN OF THE EDITORIAL BOARD.

Advertising, News Releases: Advertisements and news releases will not be published in the Journal.

CONTENTS

ARTICLES

- Endangered, Threatened, and Special Concern Plants
of Alabama
John D. Freeman, Ann Sessler Causey, John W.
Short, and Robert R. Haynes 1
- ^{65}Zn Excretion as an Indirect Measurement of Q_{10}
in the Isopod, *Armadillidium vulgare* (Latreille)
Nitaya Lauhachinda and William H. Mason 27
- Changes in Lipids Associated with Soybean Seed
Development
John D. Weete and Reeser C. Manley 35
- Redescription of *Echiniscus virginicus* Riggin
(Tardigrada) with Notes on Life History,
Range, and Geographic Variation
D. Christenberry and W. H. Mason 47

ENDANGERED, THREATENED, AND SPECIAL CONCERN
PLANTS OF ALABAMA¹

John D. Freeman, Ann Sessler Causey, and John W. Short

*Department of Botany and Microbiology
Auburn University Agricultural Experiment Station
Auburn, AL 36830*

Robert R. Haynes
*Department of Biology
University of Alabama, University, AL 35486*

A symposium on endangered and threatened plant species of Alabama was held at Tuscaloosa in May 1975, and a list published (Thomas, 1976). Since errors and inconsistencies in the spelling of certain scientific names and nomenclatural authority citations as well in distributional data and taxonomic treatment limit the usefulness of this list, we have revised it to augment the information about geographical distribution, to provide a document with fewer orthographic errors, and to add 49 species considered worthy of inclusion. We gratefully acknowledge the help of several participants of the 1975 symposium, including Dr. Robert Kral (Vanderbilt University), Dr. Michel LeLong (University of South Alabama), and Dr. Kenneth Landers (Jacksonville State University), for their careful review and criticism of this manuscript. We are greatly indebted to them and to David Whetstone (Jacksonville State University) for unselfishly making contributions to this revision based upon their own research on the Alabama flora. Besides publications cited elsewhere in this paper, collection records reported by Kral (1976) in particular document many localities included by Thomas (1976) as well as the present authors.

This list follows more or less the same sequence of taxa as the original list under the major categories of endangered, threatened, and special concern species. *Endangered* species are in danger of extinction in all or at least significant portions of their ranges in Alabama. *Threatened* species are likely to become endangered in Alabama in the foreseeable future. Species of *special concern* are those that are rare in Alabama although possibly more common outside the state and thus need to be monitored because they appear likely candidates for one of the first two categories unless voluntarily or legally protected from continued habitat alteration and destruction. Treatment within each major category is by descending taxonomic rank. Pteridophytes as treated here include ferns and other vascular cryptogams sometimes (perhaps inappropriately) referred to as "fern allies." Spermatophytes include all seed plants and are divided into the gymnosperms and the angiosperms (monocots and dicots). Within the taxonomic categories indicated above, plants are arranged alphabetically by family, and within each family alphabetically by genus and species, respectively.

¹Manuscript received 8 November 1978; accepted 13 December 1978.

Endangered, Threatened, and Special Concern Plants

Only scientific names are given here; unfortunately, most rare species are not well enough known to have common names. Detailed descriptions and additional range data may be obtained from various manuals (Small, 1933; Radford et al., 1968; Fernald, 1950; Gleason and Cronquist, 1963), and specific references cited in the text. The species included herein have been compared with a list prepared by the Smithsonian Institution (Department of the Interior, 1975), and the status of each under the Endangered Species Act of 1973 is indicated after each name in the first two categories by a parenthetical "E" for endangered, "T" for threatened, or "NL" for not listed. Since the Federal list does not have a special concern category, official status is noted only in the few cases among Special Concern Plants when they were listed as threatened or endangered by Smithsonian botanists. Other information about each species includes the habitat and counties of known occurrence.

Our list includes 49 species (30 in the endangered and threatened categories) and 303 new county distribution records not in the Thomas (1976) list. These additions are based on published records and field and herbarium research since 1975 on Alabama pteridophytes by Short and Freeman (1977) and Short (1978); on plants of the Cahaba River area in central Alabama by Sessler (1978); on aquatic plants by Haynes; and on general floristic work throughout the State by Freeman as well as on information provided by the contributors acknowledged above. Species added and county records that are new are indicated by an asterisk (*) after either the species name (in which case all counties indicated are new) or the specific county cited. Such records are documented by voucher specimens deposited in the Auburn University Herbarium (AUA), the University of Alabama Herbarium (UNA), the institutional herbaria of contributors, or presumably elsewhere when additional counties were obtained from published accounts. In a few cases we have included county names based on reliable sight records by one or more of the authors or contributors. Likewise, we have indicated our doubts regarding some previously listed counties for which there are no recent observations or collections.

Relatively few changes of status are proposed, except for the addition of several pteridophytes and aquatic plants, which were all but overlooked in 1975 due to insufficient collection data. Ten species included in the Federal list but omitted from ours are presented as Appendix I; they are either not documented for Alabama by specimens we have seen or are considered too common to be included in our list. Appendix II includes eleven species that we believe possibly no longer present in the Alabama flora, although old collections may exist in various herbaria, and three other species excluded for various reasons.

ENDANGERED SPECIES (61)

Pteridophyta Aspidiaceae

Oryopteris australis (Wherry) Small* (NL). Swamps and damp, rocky woods. Cherokee.

Dryopteris campyloptera (Kunze) Clarkson* (NL). Bases of sandstone cliffs in cool, shady ravines. Franklin and Winston.

Dryopteris spinulosa (Mueller) Watt* (NL). Stream banks in cool, shaded ravines. Lawrence and Marion.

Leptogramma pilosa (Martens & Galeotti) Underwood var. *alabamensis* (Crawford) Wherry (NL). Fissures in Pottsville sandstone cliffs, damp and well shaded, along West Sipsey Fork of Black Warrior River (colloquially and erroneously called "West Fork" of Sipsey River or simply Sipsey River, which is a different stream located in counties westward of known localities for this species). Winston (Short and Freeman, 1978a).

Aspleniaceae

Phyllitis scolopendrium (L.) Newman var. *americanum* Fernald* (NL). Rocks and organic soil near limesink caves. Jackson.

Equisetaceae

Equisetum arvense L.* (NL). Limestone bluffs and well-drained, deep sands around a sandstone spring. Greene, Marengo, and Morgan (Dean, 1969; Whetstone, 1978).

Lycopodiaceae

Lycopodium lucidulum Michaux* (NL). Moist woods or damp, rocky soil in cool, shady ravines. Jackson and Winston.

Selaginellaceae

Selaginella riddellii van Eseltine (NL). On sandstone or granitic flat-rocks or in sand. Cullman, Franklin, Lee, Marion, and Shelby. Plants of this species were apparently misidentified and previously listed as *S. tortipila* A. Braun (Thomas, 1976), but the latter species does not occur in Alabama.

Spermatophyta Angiospermae Monocotyledoneae Amaryllidaceae

Hymenocallis coronaria (LeConte) Kunth (E). Shallows of swift-flowing streams or rivers. Bibb.

Cyperaceae

Rhynchospora crinipes Gale (E). Savannas, flatwoods. Mobile.

Hydrocharitaceae

Elodea canadensis Michaux* (NL). Lakes and streams. Jackson.

Endangered, Threatened, and Special Concern Plants

Liliaceae

- Lilium iridollae* M. G. Henry (E). Acidic swamp woodland clearings. Baldwin, Covington and Escambia*.
- Lilium superbum* L. (NL). Bogs, seeps, clearings in rich woods, and peaty meadows. Butler, Escambia, Geneva, Henry, Houston, Lee*, Macon*, Sumter, and Tallapoosa*.
- Trillium pusillum* Michaux (NL). Alluvium of low woods. Madison.
- Trillium reliquum* Freeman* (NL). Wooded floodplains along river and smaller streams. Henry.

Orchidaceae

- Epidendrum conopseum* R. Brown (NL). Rich hammock woods and bottoms. Baldwin and Mobile.

Poaceae

- Andropogon arctatus* Chapman* (E). Low pinelands. Covington.

Potamogetonaceae

- Potamogeton robbinsii* Oakes* (NL). Streams of the Mobile Delta. Baldwin.

Dicotyledoneae Aquifoliaceae

- Ilex amelanchar* M. A. Curtis (E). Swamp woodlands and acid areas. Mobile and Washington.

Araliaceae

- Panax quinquefolius* L. (NL). Rich mesic forest. Calhoun*, Cherokee*, Cleburne*, DeKalb*, Etowah*, Franklin, Jackson, Jefferson*, Lee*, Madison*, Marshall*, Monroe*, Tuscaloosa*, and Walker*.

Aristolochiaceae

- Hexastylis speciosa* Harper (E). Sandy loam, usually acidic, in rather open pine-hardwoods on well-drained situations above acidic streams. Autauga, Chilton, and Dallas*.

Asclepiadaceae

- Matelea alabamensis* (Vail) Woodson (E). Hillsides and thickets in sandy soil. Dale. Previously listed as *Cyclodon alabamense* (Vail) Small (Thomas, 1976).

Asteraceae [Compositae]

- Aster chapmanii* T. & G. (NL). Black, wet sandy peat of pineland savannas. Geneva and Houston.

- Aster eryngiifolius* T. & G. (NL). Black, wet sandy peat of pineland savannas. Covington, Geneva, and Houston.
- Echinacea laevigata* (Boynton & Beadle) Blake (NL). Woodland openings. Cherokee*, Jackson, and Tuscaloosa*.
- Jamesianthus alabamensis* Blake & Sherff (E). Streambanks; wet, sunny places where streams flow over limestone or shale. Colbert and Franklin.
- Marshallia mohrii* Beadle & Boynton (E). Peaty open places, moist. Cherokee, Cullman, and Walker* (Whetstone, 1978).

Brassicaceae [Cruciferae]

- Arabis perstellata* E. L. Braun (NL). Limerock bluffs and drained bottoms. Bibb.
- Leavenworthia alabamica* Rollins var. *brachystyla* Rollins (E). Limestone outcrops and glades. Marshall and Morgan*.
- Leavenworthia crassa* Rollins var. *crassa* (E). Limestone glades. Marshall.
- Leavenworthia exigua* Rollins var. *lutea* Rollins (E). Around limestone outcrops. Jefferson and St. Clair.
- Lesquerella densipila* Rollins (E). Fields, pastures in calcareous districts. Franklin and Marshall.
- Lesquerella lyrata* Rollins (E). Fields and pastures in calcareous districts. Franklin.

Caprifoliaceae

- Viburnum bracteatum* Rehder (E). Banks of the Coosa River. Etowah.

Caryophyllaceae

- Arenaria alabamensis* (McCormick, Bozeman & Spongberg) Wyatt* (E). Shallow margins of vernal pools on granite outcrops. Randolph (McCormick, Bozeman, and Spongberg, 1971).

Crassulaceae

- Sedum nevi* Gray* (E). Rocky woods and slopes, usually over limestone. Bibb (Clausen, 1975) and Tuscaloosa.

Ericaceae

- Rhododendron chapmani* Gray* (NL). Moist, gravelly acidic woods. Henry.
- Rhododendron prunifolium* (Small) Millais (T). Rich acidic woods. Henry and Lee*.

Euphorbiaceae

- Croton alabamensis* E. A. Smith (E). Dolomitic limestone bluffs, glades, and open woods. Bibb and Tuscaloosa.
- Croton elliotii* Chapman* (E). Open pinelands. Houston.

Endangered, Threatened, and Special Concern Plants

Fabaceae [Leguminosae]

Psoralea simplex Nuttall (NL). Low, wet pinelands and savannas. Mobile and Washington.

Gentianaceae

Gentiana elliottii Chapman (NL). Rich low woods and bottoms. Covington, Dale, Geneva, Houston, Lee (?), and Tuscaloosa*.

Gentiana saponaria L. (NL). Rich low woods and swales, usually in moist, sunny situations. Calhoun*, Cherokee*, Cleburne*, DeKalb, Jackson, Lee*, Shelby, St. Clair*, and Tuscaloosa*.

Gentiana villosa L. (NL). Dryish upland woods, usually oak-pine-hickory. Jefferson, Lee, Mobile*, and Shelby (LeLong, 1977).

Lamiaceae [Labiatae]

Synandra hispidula (Michaux) Britton (NL). Rich woods: usually rocky, wet places over limestone. Jackson.

Malvaceae

Hibiscus coccineus Walter (NL). Emergent from shallow limestone ponds. Covington.

Onagraceae

Oenothera grandiflora Aiton (NL). Rich low woods or even rich mesic woods. Baldwin and Sumter.

Plantaginaceae

Plantago cordata Lam. (NL). Creek banks in shade or full sun. Cherokee*, Colbert, and Franklin.

Polemoniaceae

Phlox pulchra Wherry (E). Acidic, sandy, open oak-pine woods or arenaceous shale outcrops in the same. Autauga, Bibb, Butler, Shelby, and Tuscaloosa.

Polygonaceae

Eriogonum longifolium L. var. *harperi* (Goodman) Reveal (E). Limerock outcrops and surrounding calcareous clearings or open woods. Colbert and Franklin. Previously listed as *E. harperi* Goodman (Thomas, 1976).

Portulacaceae

Talinum appalachianum W. Wolf (E). Gneissal outcrops. Chilton* and Coosa.

Primulaceae

Lysimachia fraseri Duby (NL). Woods and slopes over sandstone. Calhoun*, Talladega*, and St. Clair* (Whetstone, pers. comm.).

Ranunculaceae

Aconitum uncinatum L. (NL). Rich woods and creek banks over limestone bedrock. Blount and DeKalb.

Hydrastis canadensis L. (NL). Rich mesic woods, usually over basic bedrock. Jackson, Lawrence*, and Marshall.

Rosaceae

Neviusia alabamensis Gray (T). Rich limerock woods and bluffs. DeKalb, Jackson, Madison, and Tuscaloosa.

Sarraceniaceae

Sarracenia alabamensis Case & Case (NL). Wet sphagnum bogs, clearings. Autauga and Chilton. Often treated as *S. rubra*, sometimes as var. *alabamensis*.

Sarracenia oreophila (Kearney) Wherry (E). Acidic wet places along streams, openings in low woods. Cherokee, DeKalb, Jackson, and Marshall*. Probably extirpated in Cherokee, and the Marshall locality doubtfully a natural population (Whetstone, pers. comm.).

Saxifragaceae

Parnassia asarifolia Vent (NL). Seepy, acid streambanks and sphagnum bogs, in woods. Calhoun*, Cleburne*, Jackson, and Lee* (Freeman, 1978).

Parnassia caroliniana Michaux (NL). Open or lightly wooded slopes. Choctaw (?).

Parnassia grandifolia DC.* (NL). Along streams in deciduous woods over dolomitic limestone. Bibb (Freeman, 1978).

Schisandraceae

Schisandra glabra (Brickell) Rehder (T). Rich bluff woods, usually over limestone, or alluvium. Bibb, Clarke*, DeKalb*, Marengo*, Morgan*, Lawrence*, and Sumter (Clark, 1971; Duncan, 1975).

THREATENED SPECIES (69)

Pteridophyta
Aspidiaceae

Dryopteris goldiana Gray* (NL). Wooded rocky slopes, flats, and stream banks. Blount, Cherokee, Jefferson, and Lawrence.

Endangered, Threatened, and Special Concern Plants

Aspleniaceae

- Asplenium bradleyi* D. C. Eaton (NL). Crevices in bare, acidic, non-calcareous cliffs. Clay*, Cleburne*, DeKalb*, Etowah*, Jackson*, and Talladega*.
- Asplenium ebenoides* R. P. Scott (T). Cool crevices of calcareous and conglomerate rocks: moist shaded areas. Hale* (Wherry and Trudell, 1930), Jefferson, and Marion*.
- Asplenium nuda-muraria* L. (NL). Crevices in calcareous rocks. Bibb*, Colbert*, DeKalb*, Etowah*, Hale*, Jackson*, Marshall*, Morgan*, and Winston*.

Hymenophyllaceae

- Trichomanes boschianum* Sturm ex Bosch (NL). Shaded moist crevices and hollows in acidic rocks, usually sandstone. Colbert*, Cullman*, Etowah*, Franklin, Hale*, Jackson*, Jefferson*, Lamar*, Lawrence*, Marion, Morgan*, and Winston. Although limited to a very narrow ecological niche, the number of counties where this and the next inconspicuous fern species are known to occur warrants their removal from the endangered category (Thomas, 1976).
- Trichomanes petersii* Gray (NL). Shaded moist crevices in acidic rocks, usually sandstone. Cleburne*, DeKalb*, Etowah*, Franklin*, Lamar*, Lawrence*, Marion*, Marshall*, Walker*, and Winston.

Isoetaceae

- Isoetes melanospora* Engelman* (NL). Seasonal pools of granite outcrops. Randolph.

Lycopodiaceae

- Lycopodium obscurum* L.* (NL). Moist to dry humus in rich woods. DeKalb, Jackson, and Marshall.
- Lycopodium porophyllum* Lloyd & Underwood (NL). Pockets and ledges in shaded sandstone cliffs. Franklin and Winston*.

Pteridaceae

- Cheilanthes alabamensis* (Buckley) Kunze (NL). Dry calcareous cliffs and rocks. Bibb*, Blount*, Calhoun*, Cherokee*, Clarke*, Colbert*, Etowah*, Jackson*, Jefferson*, Lauderdale, Shelby*, and Winston*.

Schizaeaceae

- Lygodium palmatum* (Bernhardi) Swartz (NL). Sandy or peaty acid soil at swamp margins and stream banks. Cherokee and Jackson. The lower Coastal Plain counties (Baldwin and Mobile) reported for this species by Dean (1969) probably represent *L. japonicum*.

Spermatophyta
Angiospermae
Monocotyledoneae
Araceae

Acorus calamus L.* (NL). Shallow water of streams and rivers. Baldwin, Calhoun, and Limestone.

Peltandra sagittaeifolia (Michaux) Morong* (NL). Pineland swamps near coast. Baldwin.

Arecaceae [Palmae]

Rhapidophyllum hystrix (Pursh) H. Wendl. & Drude (T). Sandy low woods, higher places in alluvial woods. Autauga*, Bibb (?), Choctaw*, Covington, Geneva, Henry*, Houston, Lee*, Lowndes*, Macon*, Pike, and Russell*. Also reported from Barbour, Bullock, Butler, Coffee, Conecuh, and Monroe (Harper, 1905; Shuey and Wunderlin, 1977).

Cannaceae

Canna flaccida Salisb. (NL). Low places: swamps near coast; full sun or light shade. Baldwin and Mobile.

Cyperaceae

Carex baltzellii Chapman (T). Sandy, loamy rich ravine slopes. Dale, Geneva, and Houston.

Carex purpurifera Mackenzie* (T). Open, dry, rich woodlands, in calcareous soil. DeKalb, Jackson, Madison, and Marshall.

Juncaceae

Juncus gymnocarpus Coville (NL). Swamp woodlands. Covington, Dale, Houston, and Mobile* (LeLong, 1977).

Liliaceae

Disporum maculatum (Buckley) Britton (NL). Rich woods. Jackson.

Lilium philadelphicum L.* (NL). Wet thickets and meadows, mainly upland provinces, rarely Coastal Plain. Jackson.

Trillium erectum L. var. *sulcatum* Barksdale (NL). Rich acidic woods in Cumberland Plateau. DeKalb*, Madison*, and Marshall (?).

Trillium lancifolium Raf. (NL). Usually alluvial woods, rarely wooded slopes. Choctaw, Etowah*, Greene, Houston*, Lawrence (?), Marengo*, Perry*, Sumter, and Tuscaloosa*.

Trillium vaseyi Harbison* (NL). Rich talus slopes and alluvium. Lee.

Orchidaceae

Cleistes divaricata (L.) Ames (NL). Acidic open low woods and bogs. Autauga, Baldwin, Escambia*, and Mobile.

Cypripedium acaule Aiton (NL). Acidic woods, usually mountains and plateau. DeKalb* and Jackson*.

Endangered, Threatened, and Special Concern Plants

Cypripedium calceolus L. var. *pubescens* (Willd.) Correll (NL). Well-drained loams, thickets--local throughout. Clarke, Cleburne*, Jackson, and Talladega.

Poaceae [Gramineae]

Panicum nudicaule Vasey (T). Mucky soil of swampy, acidic creek bottoms. Baldwin*, Mobile*, and Washington.

Stemonaceae

Croomia pauciflora (Nuttall) Torrey (T). Rich woods and ravines over various substrates, especially limestone. Chilton*, Choctaw, Clarke, Coosa*, DeKalb*, Etowah, Lee*, Monroe*, Tallapoosa*, Tuscaloosa, and Wilcox. Previously listed among the dicots in the family Croomiaceae (Thomas, 1976).

Xyridaceae

Xyris drummondii Malme (T). Wet, acid seeps in sandy or sphagnum sites: full sun. Baldwin, Covington, Geneva, Mobile, and Washington.

Xyris scabrifolia Harper* (T). Wet pinelands: sandy peats, sphagnum bogs, and seepage areas. Baldwin, Conecuh, and Mobile.

Dicotyledoneae

Apiaceae [Umbelliferae]

Ptilimnium fluviatile (Rose) Mathias (T). Banks and bars of swift, acidic streams. Cherokee, DeKalb, Jackson, and Lee*.

Brickellia cordifolia Elliott (T). Open beech-magnolia woods and adjacent clearings. Butler, Dale, Lee (?), Macon*, and Tuscaloosa*.

Cacalia diversifolia T. & G. (T). Creek and river bottoms. Houston.

Echinacea pallida Nuttall (NL). Chalk prairies. Calhoun*, Greene, Marengo, and Sumter*.

Rudbeckia auriculata (Perdue) Kral (T). Clearings in acidic low woods; wet savanna ditches. Barbour, Butler, Covington, Geneva, Pike, and St. Clair*.

Silphium confertifolium Small* (T). Dry soil. Choctaw, Hale, and Sumter.

Viguiera porteri (Gray) Blake (T). Granite outcrops. Chambers and Randolph.

Brassicaceae [Cruciferae]

Arabis georgiana Harper* (T). Shaded river banks. Bibb.

Leavenworthia alabamica Rollins (T). Limestone glades. Franklin and Lawrence.

Leavenworthia torulosa Gray (T). Thin soil over limestone; cedar glades. Madison.

Warea sessilifolia Nash (E). Pinelands: coastal plain, scattered localities. Pike*.

Caryophyllaceae

Arenaria godfreyi Shinnars (T). Seepage slopes in marl woods. Pickens*.
Pieris phillyreifolia (Hooker) DC. (T). Cypress-*Ilex myrtifolia* woods.
Baldwin*, Covington, Escambia*, Geneva, Houston*, and Mobile*
(Clark, 1971; Duncan, 1975). Probably no longer present in Baldwin
and Mobile (LeLong, pers. comm.).

Fabaceae [Leguminosae]

Astragalus tennesseensis Gray (T). Limestone glades. Morgan.
Petalostemum foliosum Gray (E). Wet places in limestone glades. Morgan.

Fagaceae

Quercus georgiana M. A. Curtis (T). Granite outcrops. Chambers* and
St. Clair.

Gentianaceae

Sabatia brevifolia Raf. (NL). Sandy openings in longleaf pine wood-
lands, hills, and savannas. Baldwin.

Hypericaceae

Hypericum dolabriforme Vent. (NL). Cherty, open places. Cherokee and
Jackson* (Whetstone, 1978).
Hypericum nitidum Lam. (NL). Acidic swales, bogs, savannas. Baldwin,
Bibb*, Dale, Geneva, Houston, Mobile, and Tallapoosa*.

Lamiaceae [Labiatae]

Scutellaria alabamensis Alexander (NL). Moist clearings in oak-pine
flats. Bibb*, Etowah, Shelby*, and Tuscaloosa*.
Utricularia floridana Nash* (NL). Low pH natural ponds. Covington and
Mobile.
Utricularia inflata Walter* (NL). Lakes. Geneva and Mobile.
Utricularia purpurea Walter* (NL). Low pH streams and lakes. Baldwin
and Mobile.
Utricularia resupinata Greene* (NL). Sandy soil at edge of natural
lakes. Covington.

Linaceae

Linum sulcatum Riddell var. *harperi* (Small) C. M. Rogers (T). Basic
soils in open, dry habitats. Marengo.

Melastomataceae

Rhexia salicifolia Kral & Bostick (T). Sandy shores of limesink ponds.
Covington and Houston.

Endangered, Threatened, and Special Concern Plants

Onagraceae

Ludwigia arcuata Walter (NL). Pond banks, sandy peat, peat muck.
Geneva and Mobile.

Papaveraceae

Stylophorum diphyllum (Michaux) Nuttall (NL). Rich limestone woods.
Jackson and Madison*.

Portulacaceae

Talinum mengesii W. Wolf (T). Granite and sandstone outcrops. Chambers,
DeKalb, Franklin, Jackson, Jefferson*, Lee*, Randolph, and Tallapoosa.

Ranunculaceae

Thalictrum debile Buckley (T). Mesic woodlands in blackbelt, sometimes
low places in hardwoods north. Greene, Hale, Lawrence, Sumter, and Wilcox.

Rhamnaceae

Sageretia minutiflora (Michaux) Trelease (NL). Seastrand beaches.
Mobile.

Santalaceae

Nestronia umbellula Raf. (T). Open, sandy, acidic oak-hickory-pine
woods. Barbour*, Blount*, Cherokee, Cullman*, DeKalb, Jackson,
Lee*, and Winston* (Clark, 1971).

Sarraceniaceae

Sarracenia psittacina Michaux (T). Bogs, Coastal Plain. Baldwin,
Concuh, Covington*, Escambia*, Geneva, Mobile, and Washington.
Sarracenia rubra Walter (T). Bogs, Coastal Plain: scattered localities
throughout. Baldwin* and Washington*. Collections from Autauga
and Chilton (Thomas, 1976) are evidently *S. alabamensis*, which is
considered endangered.

Saxifragaceae

Heuchera longiflora (Rydb.) Rosend. (NL). Rich, sandy, acidic woods;
bluffs. Talladega.

Ribes curvatum Small (NL). Sandy, rocky slopes in mountains. Cleburne,
Jackson, Marshall*, and Talladega (Clark, 1971).

Theaceae

Gordonia lasianthus (L.) Ellis (NL). Pocosin borders. Baldwin, Covington*,
Geneva, and Mobile (Clark, 1971).

Ulmaceae

Momisia iguanea (L.) Rose & Standley (NL). Rises in beach strands.
Baldwin and Mobile.

SPECIES OF SPECIAL CONCERN (131)

Pteridophyta

Aspidiaceae

Athyrium pyenocarpon (Sprengel) Tidestrom*. Rich wooded ravines, alluvial flats, and limestone slopes. Blount, Cherokee, Colbert, DeKalb, Lawrence, Limestone, Madison, Marshall, Morgan, Tuscaloosa, and Winston.

Cystopteris tennesseensis Shaver*. Damp, shaded calcareous rocks and cliffs. Colbert, Jackson, Limestone, Morgan, and Winston (Short and Freeman, 1978b).

Dryopteris ludoviciana (Kunze) Small*. Swamps and damp woods. Conecuh, Crenshaw, and Houston.

Thelypteris dentata (Forskål) E. P. St. John*. Damp woods, shaded sinks, and disturbed ground. Baldwin, Clarke, Crenshaw, and Mobile.

Thelypteris ovata E. P. St. John ex Small. Damp wooded limestone ledges, bluffs, slopes, and ravines. Clarke, Conecuh, Covington, Crenshaw, Escambia, Mobile, Monroe, Sumter, and Washington.

Thelypteris quadrangularis (Fee) Schelpe*. Wooded rocky slopes, swamp margins, and disturbed ground. Baldwin, Henry, Lee, Mobile, Pike, and Washington.

Isoetaceae

Isoetes butleri Engelmann*. Calcareous rocks and glades. Franklin and Morgan (Kral, 1973; Baskin and Baskin, 1978).

Isoetes engelmannii A. Braun*. Temporary pools, bogs, marshes, and wet ditches. Conecuh, DeKalb, Franklin, and Marshall.

Isoetes melanopoda Gay & Durieu. Low places in oak-pine flats. Cherokee.

Isoetes piedmontana (Pfeiffer) Reed*. Shallow, seasonally wet depressions in granitic flat rocks. Lee and Randolph.

Lycopodiaceae

Lycopodium cernuum L. Sphagnum seeps, moist slopes of ditches and roadbanks. Baldwin*, Clarke*, Crenshaw*, Escambia*, Mobile, and Washington.

Lycopodium flabelliforme (Fernald) Blanchard. Dry woods and slopes, often under pines. Clay*, Cleburne*, DeKalb*, Jackson*, Lauderdale*, Lawrence*, Lee*, Madison*, St. Clair*, and Tallapoosa*.

Ophioglossaceae

Botrychium alabamense Maxon*. Wooded slopes and old fields. Baldwin, DeKalb, Lee, and Mobile.

Endangered, Threatened, and Special Concern Plants

- Botrychium lunarioides* (Michaux) Swartz*. Dry open woods and old fields. Baldwin, Butler, Choctaw, Covington, Lee, Mobile, Tuscaloosa, and Wilcox.
- Ophioglossum crotalophoroides* Walter. Meadows and grassy slopes. Baldwin, Butler, Choctaw, Lee*, Marengo, Mobile, Tuscaloosa, and Washington. Common and semi-weedy around Mobile (LeLong, pers. comm.).
- Ophioglossum engelmannii* Prantl*. Dry calcareous clay or gravel. Blount, Chilton, Clay, Coosa, Franklin, Greene, Jefferson, Madison, Russell, and Shelby.
- Ophioglossum nudicaule* L.f.*. Lawns, pastures, fields, and pinelands. Baldwin, Greene, Lee, Mobile, Pike, and Washington.

Polypodiaceae

- Polypodium virginianum* L. Partially shaded dry rocks, cliffs, and ledges. Blount*, Cherokee, Clay, Cleburne*, Colbert*, DeKalb, Etowah*, Franklin, Hale*, Jackson, Jefferson*, Lamar*, Lawrence, Marion*, Walker*, and Winston.

Pteridaceae

- Dennstaedtia punctilobula* (Michaux) Moore*. Shaded cliff bases and cool ravines. Cullman, DeKalb, Etowah, Franklin, Jackson, Lawrence, Marion, and Winston.

Selaginellaceae

- Selaginella ludoviciana* A. Braun*. Moist pinelands and swamp margins. Baldwin, Conecuh, Crenshaw, Houston, Mobile, and Monroe (Somers and Buck, 1975).

Spermatophyta Gymnospermae Cupressaceae

- Chamaecyparis thyoides* (L.) BSP. Banks of acidic, cool streams. Baldwin, Conecuh, Escambia, and Mobile.

Pinaceae

- Pinus serotina* Michaux. Acidic low places, pocosins. Butler, Covington, and Geneva.

Angiospermae Monocotyledoneae Alismataceae

- Echinodorus parvulus* Engelm.*. Margins of natural ponds with sandy substrate. Geneva and Houston.
- Sagittaria isoetiformis* J. G. Sm.*. Shallow water of natural ponds with sandy substrate. Covington, Geneva, and Houston.

Eriocaulaceae

- Eriocaulon lineare* Small. Sandy, peaty edges of ponds. Baldwin, Covington, Escambia, Geneva, Houston, Mobile*, and Lee* (?).
Eriocaulon texense Korn. Pitcher plant bogs. Escambia, Mobile, and Washington.

Liliaceae

- Erythronium albidum* Nuttall. Rich woods, over limestone, usually alluvial, but well drained. Colbert, Franklin, and Marshall.
Erythronium umbilicatum Parks & Hardin subsp. *umbilicatum**. Rich mesic wooded slopes, usually over granite. Randolph.
Pleea tenuifolia Michaux. Pitcher plant bogs. Baldwin.
Schoenolirion croceum (Michaux) Gray. Moist grassy places; seeps in sandy and calcareous outcrops. Cherokee, Colbert, DeKalb, Franklin, Jackson, Marshall, Pike, and Sumter. Alabama plants treated here as *S. croceum* represent an undescribed new species (Sherman, pers. comm.).
Trillium decumbens Harbison. Rich woods, usually in shaley and/or limestone woods. Blount, Cherokee, Cullman, DeKalb*, Etowah, Jackson, Jefferson*, Shelby*, and Tuscaloosa (Freeman, 1975).
Trillium recurvatum Beck. Rich, low woods on alluvium. Colbert, Cullman, Lawrence, Pickens, and Sumter (?). The Sumter County collections may represent *T. lancifolium*, which is considered threatened.
Trillium sessile L. Rich woods on bluffs and slopes. Limestone*. This species is common north of our area but is found only in one Alabama county (Freeman, 1975); the other counties previously listed (Thomas, 1976) represent misidentified specimens mainly of *T. cuneatum* Raf., which is common in the northern half of the state.

Najadaceae

- Najas gracillima* Magnus*. Shallow water of lakes. Lee.

Orchidaceae

- Aplectrum hyemale* (Muhl. ex Willd.) Torrey. Rich woods. Bibb.
Corallorhiza wisteriana Conrad. Moist, shady areas in rich ravines. DeKalb*, Etowah*, Hale*, Marshall*, Jackson*, and Tuscaloosa (Whetstone, 1978).
Isotria verticillata (Muhl. ex Willd.) Raf. Moist hardwood slopes, stream margins. Chilton* and DeKalb*.
Orchis spectabilis L. Rich woods, usually over limestone. Cleburne*, Jackson*, Lawrence, Madison, Marshall, and Winston.
Platanthera integra (Nuttall) Gray ex Beck. Swamps, pine barrens, flatwoods. Mobile. Previously listed as *Habenaria integra* (Nuttall) Sprengel (Thomas, 1976).
Platanthera lacera (Michaux) Gray. Grassy, low meadows. Geneva*, Jackson*, Lee, and Walker. Previously listed as *Habenaria lacera* (Michaux) Lodd. (Thomas, 1976).
Platanthera peramoena (Gray) Gray. Low clearings. Lauderdale* and Madison. Previously listed as *Habenaria peramoena* Gray (Thomas, 1976).

Endangered, Threatened, and Special Concern Plants

Ponthieva racemosa (Walter) Mohr. Low woods, usually well-drained silts in limestone districts. Clarke.

Poaceae

Manisuris tuberculosa Nash (T). Low places in pineland savannas. Baldwin, Covington, and Geneva.

Xyridaceae

Xyris longisepala Kral. Edges of limestone sink ponds. Covington and Houston.

Dicotyledoneae Acanthaceae

Dyschoriste oblongifolia (Michaux) Kuntze. Longleaf pine sandhills. Henry and Houston.

Anacardiaceae

Cotinus obovatus Raf. Limerock outcrops, usually on xeric south- or southwest-facing slopes. Jackson*, Madison*, and Morgan* (Clark, 1971).

Rhus typhina L. Calcareous bluff woods along the Tennessee River. Colbert and Lawrence* (Clark, 1971).

Apocynaceae

Amsonia rigida Shuttlew. Acidic low clearings in woods. Geneva.

Araliaceae

Aralia racemosa L. Rich ravine woods, usually acidic. DeKalb and Marshall.

Asteraceae [Compositae]

Aster spectabilis Aiton. Dryish, sandy, open oak-pine woods, around sandrock outcrops. DeKalb.

Echinacea purpurea (L.) Moench. Meadows and clearings in rich woods. Calhoun*, Jackson, Lee*, and Marshall.

Liatis chapmanii (T. & G.) Kuntze. Sandy pinelands, longleaf pinehills. Baldwin and Escambia.

Liatis cylindracea Michaux. Calcareous glades. Bibb.

Ratibida colummifera Wootton & Stanley. Blackbelt pastures. Lowndes. Also from "median of highway" in Etowah county (Whetstone, 1978).

Rudbeckia heliopsidis T. & G. (T). Around sandrock outcrops in sandy, peaty seeps. Cherokee, DeKalb, and Jackson.

Rudbeckia mollis Elliott. Sandy longleaf pine hills, clearings. Henry and Houston.

Solidago elliotii T. & G. Sandy woods. Houston.

Solidago uliginosa Nuttall. Moist places in sandy woods. Jackson.

Berberidaceae

Jeffersonia diphylla (L.) Persoon. Rich mixed hardwoods over limestone. Jackson, Madison, and Marion.

Brassicaceae [Cruciferae]

Armoracia aquatica Wiegand. In shallows of backwaters, full sun. Sumter.

Buxaceae

Pachysandra procumbens Michaux. Rich woods, usually over limestone. Cleburne*, DeKalb*, Lauderdale, Lawrence*, Limestone, and Marion (Whetstone, 1978).

Capparidaceae

Cleome tenuifolia LeConte ex T. & G. Sandy, sand pine woods and clearings. Baldwin and Dale.

Caprifoliaceae

Lonicera flava Sims. Sandrock areas in the mountains. Calhoun, Cherokee, Clay*, Cleburne, DeKalb, Jackson*, Jefferson, Madison*, Marshall*, Shelby, St. Clair, Talladega, and Walker* (Clark, 1971; Duncan, 1975).

Triosteum angustifolium L. Deciduous or mixed woods or openings on basic and neutral soils. DeKalb* and Etowah*.

Viburnum obovatum Walter. Bottomland woods. Houston.

Viburnum rafinesquianum Schultes. Woodlands and thickets on basic and neutral soils. Etowah* (Clark, 1971).

Caryophyllaceae

Arenaria uniflora (Walter) Muhl. Sandrock or granitic outcrops. Chambers, DeKalb, Jackson, and Randolph.

Silene ovata Pursh. Rich woods. Sumter.

Silene rotundifolia Nuttall. Sandrock ledges. Fayette.

Silene wherryi Small. Sandstone and granitic outcrop areas; always rooted in sand. Autauga, Bibb, Cherokee, Chilton, DeKalb, Jackson, Jefferson, Marshall, Montgomery, and St. Clair.

Celastraceae

Celastrus scandens L. Limerock areas, usually around bluffs and outcrops; hedgerows in calcareous pastures. Bibb, Colbert, DeKalb*, Lawrence*, and Morgan* (Clark, 1971; Duncan, 1975).

Euonymus atropurpureus Jacq. Rich woods, over limestone. Etowah*, Greene*, Jackson*, Limestone*, Montgomery*, Morgan*, and Sumter (Clark, 1971).

Endangered, Threatened, and Special Concern Plants

Clethraceae

Clethra alnifolia L. var. *alnifolia*. Pocosins, bays, and pine barrens of the Coastal Plain. Baldwin*, Escambia*, Monroe*, and Washington*.

Convolvulaceae

Cuscuta harperi Small (T). Parasitic on *Hypericum gentianoides* (L.) BSP. on sandstone rocks. Cherokee.

Ericaceae

Kalmia hirsuta Walter. Moist, acidic, sandy, peaty pocosins, savannas, and flatwoods. Baldwin, Geneva, and Mobile* (Clark, 1971). Now doubtful for Mobile (LeLong, pers. comm.).

Rhododendron austrinum (Small) Rehder (T). Low, sandy woods. Clarke*, Coffee, Conecuh*, Covington, Crenshaw*, Escambia, Geneva, Houston, Mobile*, Monroe*, and Pike (Clark, 1971). The Cleburne County record indicated by Clark probably represents the next species.

Rhododendron bakeri (Lemmon & McKay) Hume. Sandy, open oak-hickory-pine woods, summits. Cleburne and Talladega. Previously treated as *R. calendulaceum* (Michaux) Torrey (Thomas, 1976), Alabama plants may in fact be *R. cumberlandense* E. L. Braun.

Euphorbiaceae

Andrachne phyllanthoides (Nuttall) Mueller. Rocky calcareous bluffs. Bibb* and Blount.

Fabaceae [Leguminosae]

Cladrastis kentukea (Dum.-Cours.) Rudd. Bluffs in calcareous areas, usually along the rivers and streams. Colbert*, Jackson, Madison, Marshall, Monroe*, and Tuscaloosa (Clark, 1971). Previously treated as *C. lutea* (Michaux) K. Koch by various authors including both Clark (1971) and Thomas (1976), but *C. kentukea* is valid and correct (Rudd, 1971).

Gymnocladus dioica (L.) K. Koch. Rich limestone woods, ravines. Colbert and Madison.

Psoralea onobrychis Nuttall. Calcareous clearing. Jackson.

Fagaceae

Quercus arkansana Sarg. Upland sandy oak-hickory-pine forest. Autauga, Chilton*, Hale*, Pike, Sumter*, and Tuscaloosa (Clark, 1971).

Quercus bicolor Willd. Rich damp soil. Cullman* and Hale (Clark, 1971).

Quercus imbricaria Michaux. Upland calcareous outcrop woods. Blount, Calhoun*, Etowah, and Talladega* (Clark, 1971). The Geneva County record indicated by Clark is questionable.

Quercus macrocarpa Michaux. Low, blackbelt woods. Montgomery, Pickens, and Tuscaloosa.

Quercus minima (Sarg.) Small. Low, sandy savannas. Baldwin.

John D. Freeman, Ann Sessler Causey, John W. Short, and Robert R. Haynes

Quercus pumila Walter. Low, sandy savannas. Geneva, Houston, and Mobile.

Fumariaceae

Dicentra cucullaria (L.) Bernhardt. Rich woods, usually in calcareous districts. Colbert, Etowah, Jackson, Lawrence, and Marshall.

Gentianaceae

Eustoma exaltatum (L.) G. Don. Edges of salt marshes, on sand. Mobile.

Frasera caroliniensis Walter. Rich limestone woods. Colbert, DeKalb*, Franklin, Jackson, and Lawrence*. Previously treated as *Swertia carolinensis* (Walter) Kuntze by many authors including Thomas (1976), but *Frasera* is clearly distinct (Stout and Balkenhol, 1969; Threadgill and Baskin, 1978).

Sabatia difformis (L.) Druce. Low, sandy, peaty savannas. Geneva.

Sabatia foliosa Fernald. Ditches and sandy, peaty low places. Baldwin, Mobile, and Washington.

Sabatia grandiflora Small. Banks of limesink ponds. Houston.

Sabatia quadrangula Wilbur. Sandy, peaty savanna swales. Houston.

Hamamelidaceae

Fothergilla gardenii Murray (T). Edges of pocosins, or in pocosins.

Bibb* (?), Cullman* (?), Escambia, Geneva, Jackson* (?), and Lauderdale* (?) (Clark, 1971). No recent collections of this species from the questionable counties were observed by those preparing this list, and some may in fact represent localities for the next, mainly upland, species.

Fothergilla major (Sims) Lodd. Rich woods over sandstones, usually along streams and rivers. Blount*, Cherokee, DeKalb, Jackson, Marshall, and St. Clair*.

Hydrophyllaceae

Hydrophyllum appendiculatum Michaux. Rich, calcareous woods. Colbert, Jackson, and Marshall.

Hypericaceae

Hypericum lloydii (Svenson) Adams. Dry woods and pine lands, inner Coastal Plain. Tallapoosa* (Clark, 1971).

Hypericum nudiflorum Michaux ex Willd. Rich woods, usually over sand-rock or gneiss. Chilton, Etowah*, Henry*, Jefferson, and Lee (Clark, 1971).

Hypericum reductum (Svenson) Adams. Acidic pineland savannas. Baldwin and Mobile* (Clark, 1971). The Mobile record may have been based upon *H. brachyphyllum* (Spach) Steudel (LeLong, pers. comm.).

Lamiaceae [Labiatae]

Hedeoma drummondii Benth. Chalk outcrops. Marengo, Sumter, and Wilcox*.

Endangered, Threatened, and Special Concern Plants

Monarda clinopodia L. Rich woodlands, in limestone areas. Cherokee*, Etowah*, Jefferson*, Madison, Shelby*, and Tuscaloosa.

Lentibulariaceae

Pinguicula planifolia Chapman. Black peat around cypress domes, in bogs. Baldwin, Geneva, and Mobile* (LeLong, 1977).

Pinguicula primuliflora Wood & Godfrey. Sphagnum seeps, usually creek-banks, in pinelands. Baldwin, Geneva*, Washington.

Melastomataceae

Rhexia aristosa Britton. Sphagnum seeps, cypress domes. Barbour.

Onagraceae

Oenothera heterophylla Spach. Sand of clearings, fields, borrow pits, or dryish places. Greene, Pickens, and Sumter.

Orobanchaceae

Orobanche uniflora L. Rich alluvial woods. Blount, Cherokee*, DeKalb*, Mobile* (LeLong, 1977), and Tuscaloosa.

Oxalidaceae

Oxalis grandis Small. Rich woods and clearings, over limestone. Jackson and Madison.

Polygonaceae

Polygonella americana (Fisch. & Mey.) Small. Sandy clearings in woods, bluff woods. Cherokee.

Portulacaceae

Talinum calcareicum Ware. Limestone glades. Franklin, Lawrence, and Marshall.

Primulaceae

Hottonia inflata Elliott. Lakes. Greene.

Ranunculaceae

Actaea pachypoda Elliott. Rich woods, usually in limestone areas, but not exclusively. Cherokee, Choctaw, Clarke, DeKalb, Etowah, Jackson, Lawrence*, Madison, and Marion.

Anemone caroliniana Walter. Calcareous or clay soils in clearings. Lee*, Madison, and Montgomery*.

Ranunculus flabellaris Raf. Moist banks and in shallow water; in partial to almost complete shade. Greene.

Rosaceae

Spiraea tomentosa L. Bogs, wet meadows, and low woodland borders. Lauderdale* (Clark, 1971).

Salicaceae

Salix humilis Marshall. Low, open places, grassy meadows. Cleburne*, Colbert*, Cullman*, Elmore*, Lauderdale*, Limestone*, Russell*, and St. Clair (Clark, 1971).

Salix sericea Marshall. Marshes, ditches, and low woods. Lamar* and Lauderdale* (Clark, 1971).

Santalaceae

Comandra umbellata (L.) Nuttall. Grassy areas, usually in oak-hickory or oak-pine forests. Cherokee*, DeKalb, and Jackson.

Pyrolaria pubera Michaux. Sandy oak-hickory-pine woods. Cherokee, Cleburne*, DeKalb, and Jackson (Clark, 1971).

Saxifragaceae

Ribes cynosbati L. Sandy, bluff woods. Cherokee*, DeKalb*, and Jackson (Clark, 1971).

Scrophulariaceae

Agalinis heterophylla Small. Chalk prairies. Greene, Hale, Pickens, and Sumter.

Agalinis pseudophylla (Fennell) Shinnars. Low places in pineland savannas and pitcher plant bogs. Baldwin and Escambia.

Castilleja coccinea (L.) Sprengel. Moist grassy areas, swales in natural clearings, and around sandrock outcrops. Cherokee, Coosa*, DeKalb, Etowah, Jackson, and Talladega*.

Lindernia monticola Muhl. ex Nuttall. Sandstone or gneissal outcrops and adjacent clearings. Chambers, DeKalb, Jackson, and Randolph.

Penstemon multiflorus Chapman. Sandy longleaf pinelands, fields. Baldwin and Geneva.

Veronica anagallis-aquatica L. Banks of streams, over limestone. Etowah*, Jackson, and Madison.

Theaceae

Stewartia malacodendron L. Rich sandy woods, bluffs, creek banks. Barbour*, Blount*, Chilton*, Conecuh*, Crenshaw, Cullman*, Dallas*, Escambia*, Geneva*, Marion, Mobile*, Monroe*, Pike*, Shelby*, and Tuscaloosa (Clark, 1971). Probably no longer present in Mobile (LeLong, pers. comm.).

Stewartia ovata (Cav.) Weatherby. Rich sandy woods, stream margins. Cherokee, Cullman*, DeKalb, Franklin*, Jackson, Lawrence*, Marion, and Winston* (Clark, 1971).

Endangered, Threatened, and Special Concern Plants

Valerianaceae

Valeriana pauciflora Michaux. Rich, creek bank woods, mesic forest.
Madison.

Violaceae

Viola canadensis L. Rich bluff woods. DeKalb* and Tuscaloosa.

Vitaceae

Vitis munsoniana Simpson. Sandy riverbank woods. Escambia.

APPENDIX I

Species listed for Alabama by the Department of the Interior (1975) as endangered or threatened, but not treated elsewhere in the preceding list, due to lack of recent documentation.

Endangered:

Asteraceae: *Liatris provincialis* Godfrey

Brassicaceae: *Leavenworthia crassa* Rollins var. *elongata* Rollins

Lamiaceae: *Pycnanthemum curvipes* (Greene) Grant & Epling

Threatened:

Apiaceae: *Ptilimnium nodosum* (Rose) Mathias

Asteraceae: *Liatris helleri* (Porter) Porter

Solidago spithamea M. A. Curtis

Hydrophyllaceae: *Phacelia dubia* (L.) Trelease var. *georgiana* McVaugh

Hypericaceae: *Hypericum sphaerocarpum* Michaux var. *turgidum* (Small)
Svenson

Malvaceae: *Kosteletskyia smilacifolia* Gray

Poaceae: *Aristida simpliciflora* Chapman

APPENDIX II

Annotated list of species now believed to be extirpated from the Alabama flora or excluded for other reasons. Some were perhaps formerly listed (Thomas, 1976) on the basis of misidentified specimens. Any new localities for valid, rare species included here should be sufficient cause for them to be re-listed, perhaps most appropriately in the endangered category.

PTERIDOPHYTA Gleicheniaceae

Dicranopteris flexuosa (Schrad.) Underwood*. Moist, open pineland and swamp margins. Mobile. Not collected since 1920's; believed extirpated.

SPERMATOPHYTA
GYMNOSPERMAE
Cupressaceae

Chamaecyparis thyoides (L.) BSP. var. *henryae* (Li) Little. Swamp forests, extreme lower Coastal Plain. No recent collections.

ANGIOSPERMAE
Monocotyledoneae
Juncaginaceae

Triglochin striata R. & P.* Margins of brackish streams. Mobile. Believed extirpated.

Liliaceae

Lilium canadense L. Wet thickets and meadows, mainly upland provinces, rarely Coastal Plain. No collections observed.

Veratrum parviflorum Michaux. Rich, sandy woods, mixed oak-pine. Lee (?). No recent collections observed; Alabama plants may represent *V. woodii* Robbins.

Marantaceae

Thalia dealbata Roscoe. Wet ditches and margins of swamp forests. Coastal Plain: scattered localities. No recent collections.

Dicotyledoneae
Asteraceae

Coreopsis gladiata Walter. Pineland ditches, savannas, pitcher plant bogs. Baldwin, Conecuh, Covington, Geneva, Houston, Mobile, and Washington. Not a rare plant in Alabama, but perhaps becoming so with continued loss of its habitat.

Berberidaceae

Diphylleia cymosa Michaux. Seepage areas and moist coves on mixed deciduous slopes. Cherokee. Believed extirpated.

Brassicaceae

Warea amplexifolia (Nuttall) Small. Sandy, longleaf pine hills. Pike (?). No collections observed.

Ericaceae

Rhododendron atlanticum (Ashe) Rehder. Flat pinewoods and savannas, usually moist situations. No collections observed.

Endangered, Threatened, and Special Concern Plants

Haloragaceae

Myriophyllum laxum Shuttlew. ex Chapman (T). Streams. Baldwin. Believed extirpated.

Lauraceae

Lindera melissaeifolia (Walter) Blume (T). Swamp woodlands. Wilcox. Not collected since 1840's.

Primulaceae

Lysimachia graminea (Greene) Handel-Mazzetti. Moist, peaty open places. Cherokee, Cullman, DeKalb*, Franklin*, Jackson*, Lee*, and Tuscaloosa*. Doubtfully distinct from *L. lanceolata* Walter var. *lanceolata*.

Ranunculaceae

Clematis gattingeri Small. Limestone bluffs. Coosa. Not considered a good species.

LITERATURE CITED

- Baskin, J. M., and Carol C. Baskin. 1978. Geographical distribution of *Isoetes butleri* in the Southeastern United States. *Am. Fern J.* 68:7-8.
- Clark, R. C. 1971. Woody plants of Alabama. *Ann. Missouri Bot. Gard.* 58:99-242.
- Clausen, R. T. 1975. *Sedum* of North America North of the Mexican Plateau. Cornell University Press, Ithaca, NY. 742 pp.
- Dean, B. E. 1969. Ferns of Alabama, revised ed. Southern University Press, Birmingham, AL. 232 pp.
- Department of the Interior. 1975. Threatened or endangered fauna or flora: review of status of vascular plants. *Federal Register* 40: 27825-27924.
- Duncan, W. H. 1975. Woody Vines of the Southeastern United States. University of Georgia Press, Athens, GA. 76 pp.
- Fernald, M. L. 1950. *Gray's Manual of Botany*, 8th ed. American Book Co., New York, NY. xiv + 1632 pp.
- Freeman, J. D. 1975. Revision of *Trillium* subgenus *Phyllantherum*. *Brittonia* 27:1-62.
- _____. 1978. State record for *Parnassia* (Saxifragaceae) in Alabama. *Castanea* 43:191-192.

John D. Freeman, Ann Sessler Causey, John W. Short, and Robert R. Haynes

- Gleason, H. A., and A. J. Cronquist. 1963. Manual of the Vascular Plants of the Northeastern United States and Adjacent Canada. D. Van Nostrand Co., Inc., Princeton, NJ. i + 810 pp.
- Kral, R. 1973. Some notes on the flora of the southern states, particularly Alabama and middle Tennessee. *Rhodora* 75:366-410.
- _____. 1976. Additions to some notes on the flora of the southern states, particularly Alabama and middle Tennessee. *Rhodora* 78:438-456.
- LeLong, M. 1977. Annotated list of vascular plants in Mobile, Alabama. *Sida* 7:118-146.
- McCormick, J. F., J. R. Bozeman, and S. Spongberg. 1971. A taxonomic revision of granite outcrop species of *Minuartia* (*Arenaria*). *Brittonia* 23:149-160.
- Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. Manual of the Vascular Flora of the Carolinas. University of North Carolina Press, Chapel Hill, NC. xi + 1183 pp.
- Rudd, Velva E. 1971. Studies in the Sophoreae (Leguminosae) I. *Phytologia* 21:327.
- Sessler, A. H. 1978. Vascular flora of the Cahaba River area. M.S. Thesis, Auburn University, Auburn, AL. 92 pp.
- Short, J. W. 1978. Distribution of Alabama Pteridophytes. M.S. Thesis, Auburn University, Auburn, AL. 141 pp.
- Short, J. W., and J. D. Freeman. 1977. Endangered and threatened pteridophytes of Alabama. *J. Alabama Acad. Sci.* 48:69-70 (abstract).
- _____. 1978a. Rediscovery, distribution and phytogeographic affinities of *Leptogramma pilosa* in Alabama. *Am. Fern J.* 68:1-2.
- _____. 1978b. *Cystopteris tennesseensis* in Alabama. *Am. Fern J.* 68:95.
- Shuey, A. G., and R. P. Wunderlin. 1977. The needle palm: *Rhaphidophyllum hystrix*. *Principes* 21:47-59.
- Small, J. K. 1933. Manual of the Southeastern Flora. Published by the author, New York, NY. xxii + 1554 pp.
- Somers, P., and W. R. Buck. 1975. *Selaginella ludoviciana*, *S. apoda*, and their hybrids in the southeastern United States. *Am. Fern J.* 65:76-82.
- Stout, G. H., and W. J. Balkenhol. 1969. Xanthones of Gentianaceae-I. *Frasera carolinensis* Walt. *Tetrahedron* 25:1947-1960.

Endangered, Threatened, and Special Concern Plants

- Thomas, J. L. 1976. Plants. In: Endangered and threatened plants and animals of Alabama. H. Boschung, ed. Bull. Alabama Mus. Nat. Hist. 2:5-12.
- Threadgill, P. F., and J. M. Baskin. 1978. *Swertia carolinensis* or *Frasera carolinensis*? Castanea 43:20-22.
- Wherry, E. T., and H. Trudell. 1930. The *Asplenium ebenoides* locality near Havana, Alabama. Am. Fern J. 20:30-32.
- Whetstone, R. D. 1978. New or noteworthy records for the flora of Alabama. Castanea (in press).

⁶⁵ZN EXCRETION AS AN INDIRECT MEASUREMENT OF Q₁₀ IN THE
ISOPOD, *Armadillidium vulgare* (LATREILLE)¹

Nitaya Lauhachinda and William H. Mason
Department of Zoology-Entomology
Auburn University, Auburn, AL 36830

INTRODUCTION

Within limits increasing temperature accelerates most physiological processes. A parameter commonly used in describing the thermal sensitivity of these physiological processes is the temperature coefficient, or Q₁₀. The most common means of calculating Q₁₀ is by measuring oxygen consumption at two or more temperatures, but it can also be calculated from any rate process that is affected by temperatures, i.e., enzyme-catalyzed reactions, heart rates, etc.

The measurement of radionuclide excretion (bioelimination) rate as an indirect means of measuring the metabolic rate, food consumption, growth, and reproduction in animals, particularly in arthropods, was first suggested by Odum (1961). Some of the possibilities of using the turnover rate of radioisotopes as indices of various biological activities were elaborated by Odum and Golley (1963). In general, many authors have reported that increases in overall metabolic activity result in increases in excretion rate of a variety of radionuclides (Shulman et al. 1961, Michima and Odum 1963, Crossley 1966, Edwards 1967, Reichle 1967 and 1968, Burnett et al. 1969, Pulliam et al. 1969, Chew 1971, Rhodes and Mason 1971, Williamson 1975). Radionuclide elimination rates have been shown to be highly correlated with egg production (Mason and McGraw 1973, Brugh and Mason 1976, Mason et al. 1976) and feeding behavior, particularly in coprophagy (Mason and Odum 1969, Schreiber and Mason 1976).

Among the readily available radionuclides, ⁶⁵Zn has been extensively used in a variety of metabolic studies dealing with both vertebrates and invertebrates. Rhodes and Mason (1971) reported a high correlation between oxygen consumption and the rate at which ⁶⁵Zn is excreted in the wood-feeding cockroach, *Cryptocercus punctulatus* Scudder. They suggested that more refined techniques based on similar studies could be developed to indirectly determine metabolic rates of many small ectotherms released in nature and recaptured at a later time. The oxygen consumption in young plaice, *Pleuronectes platessa*, increases at higher temperatures, as do ⁶⁵Zn-elimination rates (Edwards 1967). Pulliam et al. (1969) reported a significant correlation between the elimination rate of ⁶⁵Zn and the rate of metabolism of white mice. Chew (1971) reported similar results in *Peromyscus polionotus* where the mean elimination constant for ⁶⁵Zn of exercised mice was significantly larger than that of unexercised mice.

¹Manuscript received 31 July 1978; accepted 3 October 1978.

Indirect Measurement of Q_{10}

The objective of the research reported here was to label a conveniently-sized, easily-handled arthropod with ^{65}Zn , measure the excretion of the nuclide at different temperatures, and determine if Q_{10} values calculated from these data compare favorably with those determined by other means and reported in the literature. Such a method of determining metabolic Q_{10} would be much faster and less cumbersome than the more traditional method of determining Q_{10} by measuring oxygen consumption.

MATERIALS AND METHODS

Specimens of *Armadillidium vulgare* (Latreille) were collected locally (Auburn University campus) at a single collection site from November to March, 1975-76. They were kept at room temperature (20°-23°C) in moist humus and provided with fresh lettuce and raw potato for one to two weeks prior to experimentation.

Fifty isopods were labeled with ^{65}Zn by allowing them to feed for 24 hours on shredded lettuce (10 × 10 cm piece) which had been thoroughly mixed with a 1 ml solution containing 20 μCi $^{65}\text{ZnCl}_2$. The labeled isopods were then randomly divided into two groups of 25 each. Individuals in both groups were kept separately in plastic boxes measuring 10 × 10 × 10 cm and were supplied with a combination of humus (300 cm^3) and several small pieces of lettuce. The lettuce was changed when necessary, but no change was made in the soil. The isopods in one group were held in a temperature chamber at 15°C while individuals in the other group were held similarly at 25°C.

Whole body CPM measurements were taken by transferring individuals to a clean test tube and inserting the tube directly into the deepwell of a sodium iodide crystal-equipped scintillation counter system. Utilization of a single channel analyzer assured counting only the photopeak of the radionuclide. The CPM data were collected daily for the first 4 days post labeling, then on days 7, 14, 21, and 28. The data were corrected for background and physical decay and converted to percentage of the initial ^{65}Zn burden. The bioelimination curves of ^{65}Zn for each group were obtained by plotting the mean percentages of ^{65}Zn retained against time for each experimental group.

A second group of 50 isopods was also labeled by injecting the tracer directly into the hemocoel from the ventral mid-body surface. The labeling solution was prepared by mixing 20 μCi $^{65}\text{ZnCl}_2$ in 0.3 ml water. Individuals were injected with approximately 0.006 ml of the test solution. These animals were then divided into two groups and treated identically to the first group of 50 animals.

RESULTS AND DISCUSSION

The ^{65}Zn excretion (bioelimination) curves for isopods labeled by ingestion and held at 15°C and 25°C are shown in Fig. 1. The rapid loss of tracer during the first two days repeats a pattern noted in most animals studied in this manner and probably represents the elimination of unassimilated gut material. The rapid elimination phase was then followed by a slower and more uniform loss of the tracer. It is this

latter phase of elimination which is possibly linked directly to overall metabolism.

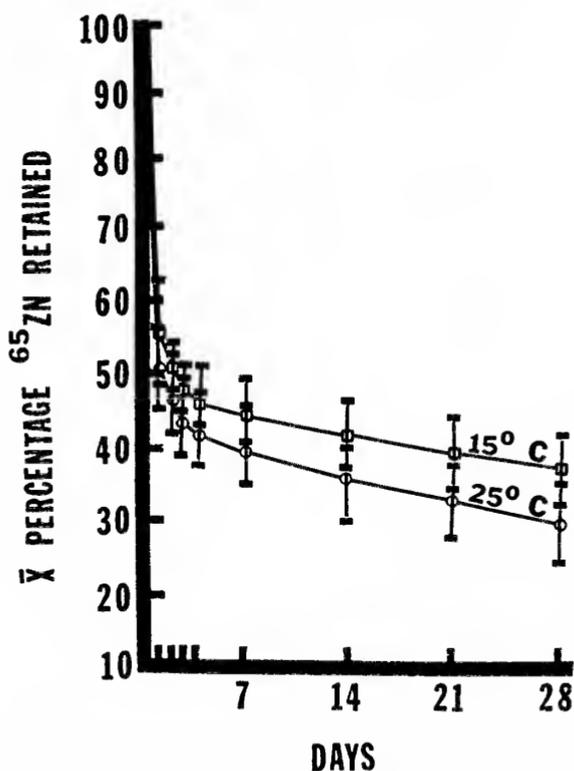


Fig. 1. ^{65}Zn excretion curves of *A. vulgare* labeled by ingestion and held at 15°C (N = 25) and 25°C (N = 21). Vertical bars = ± 1 S.E.

After two days the more rapid elimination of ^{65}Zn in those animals at the higher temperature resulted in some separation of the bioelimination curves. However, examination of the standard errors bracketing the means shows that significant differences were not approached during any phase of the experiment.

The most important comparison to make in Fig. 1 involves differences in the curves during the latter phases of the experiment, the time that excretion of the label is thought to be most closely linked to metabolic responses. In order to make this comparison, points on the bioelimination curves must be identified at which the slower and more

Indirect Measurement of Q_{10}

uniform excretion phases begin. As seen in Fig. 1, day 7 seems to satisfy this criterion for both groups. The data can then be replotted, letting the day 7 CPM values represent 100% and using the latter values to construct linear regression lines for the day 7-28 period (Fig. 2). The difference between the 15°C and 25°C groups now seems much more obvious. The mean values of the percentage of label excreted on day 28 are significantly different ($P < .01$) when compared by the student's t-test, and it is clear that a major response to temperature did occur.

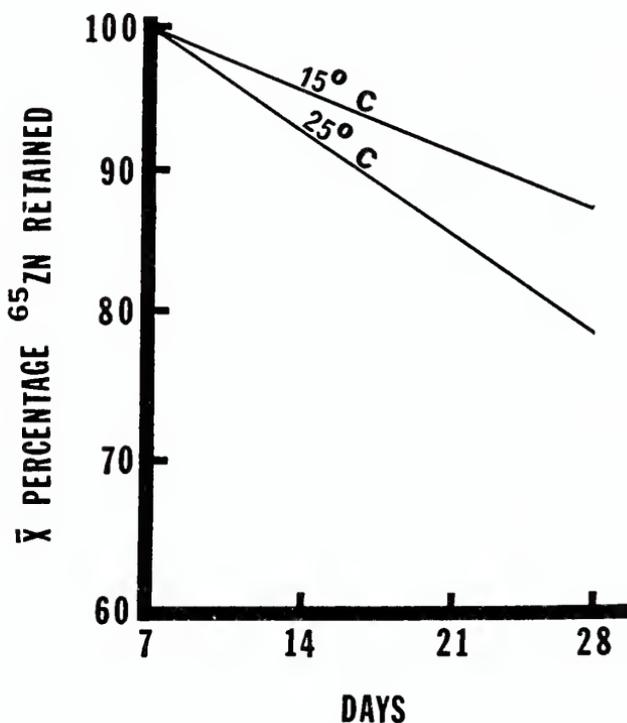


Fig. 2. Regression of ^{65}Zn excreted in *A. vulgare* labeled by ingestion and held at 15°C ($T_{b\frac{1}{2}} = 88$ days, $N = 25$) and 25°C ($T_{b\frac{1}{2}} = 50$ days, $N = 21$).

Biological half-life ($T_{b\frac{1}{2}}$) and Q_{10} values were calculated based on the Fig. 2 data. The $T_{b\frac{1}{2}}$ in the 15°C group was 88 days; the 25°C group was 50 days. The calculated Q_{10} , obtained by dividing $T_{b\frac{1}{2}}$ at the higher temperature by the $T_{b\frac{1}{2}}$ at the lower temperature, is 1.76. This Q_{10} value is very close to those calculated from oxygen consumption (1.56-1.79) by Edney (1964) for the same species acclimatized at 10°, 20°, and

30°C and measured at test temperatures of 10°, 20°, and 30°C. Wieser (1972) reported a Q_{10} of 1.76, based on ammonia produced, for females of this species measured at 20° and 30°C.

The bioelimination curves of isopods labeled by injection and held at varying experimental temperatures are shown in Fig. 3. The percent ^{65}Zn lost during the first two days was about the same (approximately 50%) as in the previous experiments, and the general shapes of the curves are very similar. This in itself was somewhat surprising since we had not anticipated an initial loss here of the magnitude expected in animals labeled by ingestion. We assume that much of this loss represents direct leakage from the site of injection; however, this is conjecture at this time.

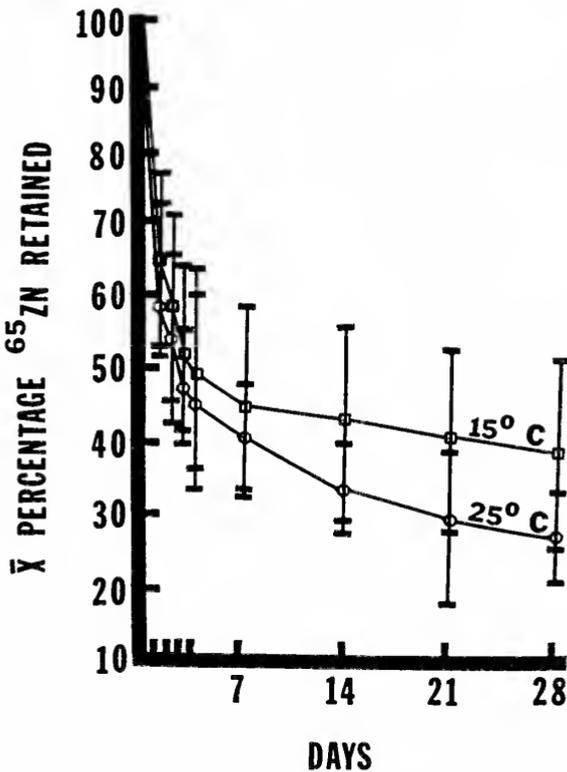


Fig. 3. ^{65}Zn excretion curves of *A. vulgare* labeled by injection and held at 15°C (N = 13) and 25°C (N = 14). Vertical bars = ± 1 S.E.

Indirect Measurement of Q_{10}

The data of Fig. 3 were also replotted as described previously for animals labeled by ingestion, using information from days 7-28 (Fig. 4). The mean values of the percentages of the nuclide excreted on day 28 are significantly different ($P < .01$) when analyzed by the Student's t-test. The $T_{b\frac{1}{2}}$ for those held at 15°C was 57 days; those held at 25°C was 30 days. The Q_{10} value calculated for this method of labeling is 1.90. This Q_{10} value seems reasonable based on what is expected of invertebrates, and also closely corresponds with Edney's (1964) data.

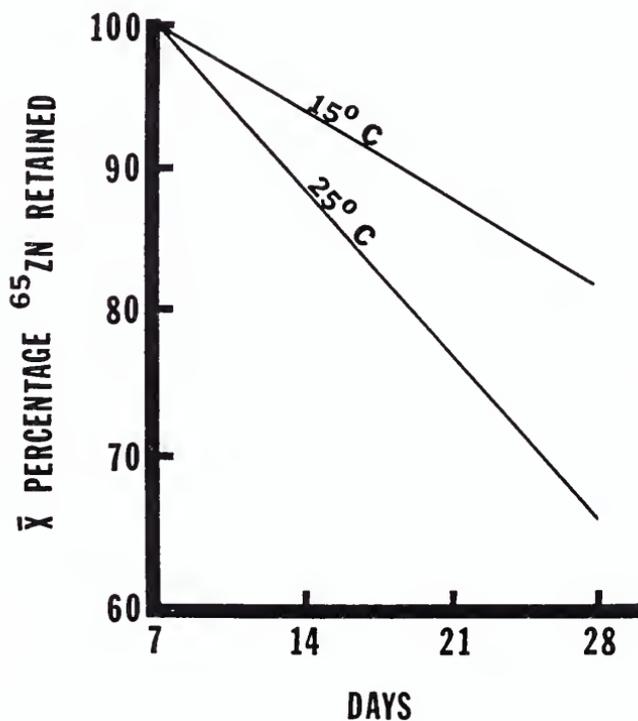


Fig. 4. Regression of ^{65}Zn excreted in *A. vulgare* labeled by injection and held at 15°C ($T_{b\frac{1}{2}} = 57$ days; $N = 13$) and 25°C ($T_{b\frac{1}{2}} = 30$ days, $N = 14$).

It is concluded that the ^{65}Zn bioelimination rates in *A. vulgare* labeled by either ingestion or injection are related to over-all metabolism and that metabolism could be accurately estimated on the basis of ^{65}Zn excretion data. *Armadillidium vulgare* can be easily labeled with ^{65}Zn by either ingestion or injection, is easy to maintain, and is

easily handled in the laboratory. The labeling techniques employed in this study seemed to produce no harmful side effects in the experimental animals.

LITERATURE CITED

- Burnett, A. M., W. H. Mason, and S. T. Rhodes. 1969. Reingestion of feces and excretion rates of ^{65}Zn in *Popilius disjunctus* versus *Cryptocercus punctulatus*. Ecology 50(6):1094-1096.
- Brugh, T. H. Jr., and W. H. Mason. 1976. Relationship of radionuclide bioelimination and reproduction rate in *Drosophila melanogaster* (Meigen). Proc. 4th Nat. Sym. on Radioecology, 209-216.
- Chew, R. M. 1971. The excretion of ^{65}Zn and ^{54}Mn as indices of energy metabolism of *Peromyscus polionotus*. J. Mammal. 52:337-350.
- Crossley, D. A. Jr. 1966. Radioisotope measurement of food consumption by a leaf beetle species, *Crysomela knabi* Brown. Ecology 47:1-8.
- Edney, E. B. 1964. Acclimation to temperature in terrestrial isopods. Part I & II. Physiol. Zool. 37:364-394, 368-394.
- Edwards, R. R. C. 1967. Estimation of the respiratory rate of young plaice (*Pleuronectes platessa* L.) in natural conditions using zinc-65. Nature 216:1335-1337.
- Mason, W. H., and E. P. Odum. 1969. The effect of coprophagy on retention and bioelimination of radionuclides by detritus-feeding animals. Proc. 2nd Nat. Symp. on Radioecology, 721-724.
- Mason, W. H., and K. A. McGraw. 1973. Relationship of ^{65}Zn excretion and egg production in *Trichoplusia ni* (Hubner). Ecology 54:214-216.
- Mason, W. H., E. M. EuDaly, and P. S-B Chiu. 1976. ^{65}Zn , ^{59}Fe and ^{54}Mn bioelimination versus egg production in *Heliothis zea*. Proc. 4th Nat. Symp. on Radioecology, 217-220.
- Mishima, J., and E. P. Odum. 1963. Excretion rate of ^{65}Zn by *Littorina irrorata* in relation to temperature and body size. Limnol. Oceanogr. 8:3-44.
- Odum, E. P. 1961. Excretion rate of radioisotopes as indices of metabolic rates in nature: biological half-life of zinc-65 in relation to temperature, food consumption, growth, and reproduction in arthropods. Biol. Bull. 121:371-372.
- _____, and F. B. Golley. 1963. Radioactive tracers as an aid to the measurement of energy flow at the population level in nature. Proc. 1st Nat. Symp. Radioecology, 403-410.

Indirect Measurement of Q_{10}

- Pulliam, H. R., G. W. Barrett, and E. P. Odum. 1969. Bio-elimination of tracer ^{65}Zn in relation to metabolic rates in mice. Proc. 2nd Nat. Symp. Radioecology, 725-730.
- Reichle, D. E. 1967. Radioisotope turnover and energy flow in terrestrial isopod populations. Ecology 48:351-366.
- _____. 1968. Relation of body size to food intake, oxygen consumption, and trace element metabolism in forest floor arthropods. Ecology 49:538-542.
- Rhodes, S. T., and W. H. Mason. 1971. ^{65}Zn excretion as an index to metabolic rate in the wood-feeding cockroach, *Cryptoecerus punctulatus*. Ann. Entomol. Soc. Am. 64:450-452.
- Schreiber, M. N., and W. H. Mason. 1976. Investigation of coprophagy and fecal pellet selection in the wood-degrading beetle, *Popilius disjunctus* (Illiger). Proc. 4th Nat. Symp. on Radioecology, 136-139.
- Shulman, J., I. L. Brisbin, and W. Knox. 1961. Effect of temperature, salinity, and food intake on the excretion of ^{65}Zn in small marine fish. Biol. Bull. 121:378.
- Wieser, W. 1972. O/N ratios of terrestrial isopods at two temperatures. Comp. Biochem. Physiol. 43A:359-368.
- Williamson, P. 1975. Use of ^{65}Zn to determine the field metabolism of the snail. *Cepaea nemoralis* L. Ecology 56:1185-1192.

CHANGES IN LIPIDS ASSOCIATED WITH
SOYBEAN SEED DEVELOPMENT^{1,2}

John D. Weete³ and Reeser C. Manley⁴

Department of Botany and Microbiology
Auburn University Agricultural Experiment Station
Auburn, AL 36830

Abstract. Changes in the lipid content of soybean (*Glycine max* (L) Merr. var. Bragg) seed during development were determined. Maximum seed dry weight was reached by 60 days after flowering (DAF). The polar lipid (phospholipid and glycolipid) content was highest at 10 to 30 DAF and then declined to become a minor lipid component of mature seed. The principal lipid component of mature seed, triglyceride, increased linearly during development to about 84% of the total lipid. The fatty acid content also increased steadily during development, reaching about 10% of the dry weight in the mature seed. Initially, fatty acids were highly saturated (ca 77%), but the degree of unsaturation increased rapidly to ca 74% of the total between 10 and 30 DAF. Predominant fatty acids of mature seed were C₁₆ (11.6%), C_{18:1} (18.8%), and C_{18:2} (56.6%). Sterols represented a minor component of the seed oil, increasing from 2.2 μ g per seed at 10 DAF to 38.0 to 41.8 μ g at 60 to 100 DAF. However, on a seed dry weight basis, the sterol content decreased with maturity from 1.3 to 0.3 mg/g, respectively, the greatest change occurring between 10 and 30 DAF. Alkanes comprised 842 μ g/kg of the dry seed tissue with C₃₁ as the predominant homologue and 305 μ g of the leaf tissue with C₂₉ and C₃₁ as the major hydrocarbon components.

INTRODUCTION

The oil content of over 160 soybean varieties has been analyzed and ranges from 17 to 20% of the dry weight in most of them (1, 4, 27, 30, 32). Although it is commercially very important, there are problems with soybean oil, compared with other economically important vegetable oils such as those from corn and peanut, because of the development of "off flavors" with aging. The decline in soybean oil quality with storage is attributable, in part, to a relatively high level of linolenic acid (α C_{18:3}) (9). It has been proposed that α C_{18:3} enhances the auto-oxidation of linoleic acid (C_{18:2}), resulting in the "off flavor" (7, 35).

¹Manuscript received 6 December 1978; accepted 25 January 1979.

²Supported by funds from an Auburn University Grant-in-Aid and Alabama State project 5-866.

³To whom all correspondence should be addressed.

⁴Present address: Park Seed Company, Greenwood, S.C.

Changes in the total seed oil content and composition of some lipid classes have been studied in several soybean varieties (16, 17, 25, 26, 29, 31, 33, 34). This study was conducted to determine changes with time in the total oil, triglyceride, and polar lipid (phospho- and glycolipid), sterol, and fatty acid composition of seed of the Bragg variety grown under field conditions in the southeastern United States.

MATERIALS AND METHODS

Growth and harvesting of plant tissues. Soybean seed (*Glycine max* (L) Merr. var. Bragg) were harvested, 30, 40, 60 and 100 days after flowering (DAF) from plants grown at the Tallassee Plant Breeding Unit of Auburn University, Tallassee, Alabama. Leaf tissue for hydrocarbon analysis and seeds collected at 10 DAF were harvested from plants growing in 23 cm pots containing soil and vermiculite (3:1 w/w) in an environmentally controlled growth chamber (35-40 klux; 23 C and 68% relative humidity (RH) day; 19 C and 98% RH night). A 16 h photoperiod was maintained until the plants were 4 to 5 weeks of age, after which flowering was induced by changing to a 12 h photoperiod. Seeds harvested from either the field or growth chamber were separated into three 10-seed groups and stored at -5 C prior to analysis.

Extraction procedures. Each 10-seed group was lyophilized and weighed before the lipid extraction. The dried sample was ground to a fine powder in a mortar and the lipids were extracted with 100 ml chloroform:methanol (2:1, v/v). After 2 h at 40-50 C with constant magnetic stirring, insoluble material was removed by centrifugation and the solvent was evaporated either under nitrogen or in a rotary flash evaporator prior to weighing the lipid.

For hydrocarbon analyses, mature intact seeds (ca 100 g) were ground as before and extracted for 1 h at room temperature with 200 ml of chloroform. The extract was treated as described above. Leaf surface wax was removed by dipping leaves (ca 40 g fresh weight) into 500 ml of chloroform for 10 s and evaporating the solvent under nitrogen.

Separation of lipid classes. Soybean seed oil (ca 200 mg), dissolved in petroleum ether, was placed on a 10 g column (50 cm × 2 cm) of silicic acid (100 mesh) prepared according to the method of Hansen and Czochanska (15). The individual lipid classes were obtained by passing the following solvents sequentially through the column: 100 ml petroleum ether (PE), 150 ml PE:diethyl ether (Et₂O) (95:5, v/v), 200 ml PE:Et₂O (75:25, v/v), 150 ml chloroform:acetone (1:1, v/v), 150 ml acetone, and 150 ml methanol.

Hydrocarbons from seeds and leaf surface wax were also isolated by column chromatography. The extracts were dissolved in n-hexane and placed on a 10 g column (50 cm × 2 cm) of silica gel (60-200 mesh) and the hydrocarbons were eluted with n-hexane. It was necessary to repeat the column procedure several times for isolation of seed oil hydrocarbons to ensure separation of the alkanes from other components of the oil.

Thin-layer chromatography (TLC) was used to purify the lipids. Portions of each fraction from the columns were applied to precoated, activated silica gel (250 μ m layer) G plates (Applied Science Laboratories, State College, PA). Neutral lipids were developed in PE:Et₂O:acetic acid (87:12:1 v/v/v) (15), and polar lipids in chloroform:methanol:acetic acid:water (80:15:5:2 v/v/v/v) (38). Lipids were detected by spraying a portion of the plate with KMnO₄ (5% in EtOH) and recovered by scraping silica gel from the corresponding non-sprayed areas of the plates and extracting with chloroform:methanol (1:1 v/v).

Preparation of samples for analysis. Total fatty acids and sterols were obtained by alkaline hydrolysis of the total lipid extract. Each sample was refluxed 8 h in 100 ml 10% KOH in 95% methanol (v/v). Un-saponifiable and saponifiable lipids were isolated in the usual way. Sterols were removed from the un-saponifiable fraction by digitonin precipitation (5). Free sterols were recovered by heating the digitonides in 10 ml dimethylsulfoxide for 1 h on boiling water bath and washing with n-hexane. Sterols in the hexane were converted to their trimethylsilyl (TMS) ether or acetate derivatives for gas chromatography-mass spectrometric analysis. TMS derivatives were prepared by dissolving ca 50 mg sterol in 1 to 3 ml "Sil-Prep" [hexamethyldisilazane:trimethylchlorosilane (3:1) in pyridine, Applied Science Laboratories, State College, PA] and allowing it to remain for 1 h at room temperature prior to analysis. Acetate derivatives were prepared by dissolving ca 50 mg sterol in 2 ml acetic anhydride in pyridine (5:1, v/v) and holding for 8 h at room temperature prior to analyses.

Fatty acids in the saponifiable fraction were converted to their methyl ester derivatives using boron trifluoride-methanol (Applied Science Laboratories, Inc.) according to the method of Metcalfe and Schmitz (28). The fatty acid methyl esters were purified by dissolving them in n-hexane which was placed on a 2 to 3 g column of silica gel (60-200 mesh), and eluting the column with benzene.

Gas chromatography-mass spectrometry (GLC-MS). Gas chromatographic analyses were conducted using either a Varian Aerograph 1400 or 2440 gas chromatograph equipped with flame ionization detectors. Hydrocarbon and sterol analyses were made on a 3 m \times 2 mm glass column packed with 3% GE SE-30 on Chromasorb Q. Injector and detector temperatures were maintained at 290 C. The oven temperature for hydrocarbon analyses was programmed from 150 to 270 C at 4 C/min and was isothermal at 250 C for sterol analyses. Fatty acid analyses were made on a 3 m \times 2 mm stainless steel column packed with 12% DEGS (diethylene glycol succinate) on Chromasorb Q. Injector and detector temperatures were 210 C and the oven temperature was 190 C isothermal.

Total sterol and lipid phosphorus analyses. Total sterols obtained by digitonin precipitation were analyzed quantitatively as free sterols using the Liebermann-Burchard reaction (21). Phosphorus in the total lipid extract was determined by the method of Chen et al. (6).

RESULTS AND DISCUSSION

Bragg soybean seed dry weight progressively increased during the first 60 DAF, but declined between 60 and 100 DAF at which time the seed were considered mature (Table 1). This result is generally in agreement with the findings for the Tamanishiki variety which reached maximum dry weight at approximately 70 DAF (25), whereas seed of the Tokati Nagaba variety achieved maximum dry weight at about 40 DAF (17). Total lipid content of Bragg seed increased very rapidly, reaching a maximum at 30-40 DAF (Table 1). This finding is considerably different from the findings with Tamanishiki (25) and Anoke (20) varieties that reached maximum lipid content at 60 to 70 DAF but similar to Tokati Nagaba (17) Acme, Cheppewa, and Harosoy 63 varieties (32) in which maximum lipid content (20.1 to 22.7%) was reached by 40 DAF and maintained through 100 DAF. This is consistent with reports showing that higher temperatures most affect soybean lipid content 20 to 30 days prior to seed maturity, possibly because that is the time of greatest lipid synthesis (2, 20). The total lipid content is also within the range reported for most soybean varieties (27, 30, 32). The oil content of mature Bragg soybean seed was reported by Nabagan and Joshi (36) and Hirota et al. (18) to be 23.2% and 24.4% (acetone-soluble lipid) of the seed dry weight, respectively. The slight variation in lipid content of this and the above reports for Bragg soybeans is probably due to differences in moisture and temperature conditions during the pod-filling stage of growth (20). In this study, abundant water was available during seed development.

With few exceptions, the major type of lipid in mature seed is triglyceride, which ranges from 10 to 70% of the tissue dry weight depending on the species (19). At 30 DAF, triglycerides in Bragg variety seed represented 6.1% of the dry weight and 27.7% of the total oil, and increased linearly to 16.8 and 83.6%, respectively, in the mature seed (Table 1). These results are similar to those reported for other soybean varieties (30, 31). The neutral lipid fraction of oil extracts of developing seed of the Anoka variety contained triglyceride, free fatty acids, sterols and unidentified lipid (30). The triglyceride component of those seeds increased rapidly during the first 55 DAF and more slowly to 98% of the neutral lipid fraction during the final 42 DAF. Similar changes in the triglyceride content of the Hawkeye variety were observed where the triglyceride content reached 85% of the total oil (31).

Polar lipid of developing Bragg soybean seed consisted primarily of phospholipid and glycolipid and decreased rapidly during seed development from 8.2% and 40.0%, respectively, of the seed dry weight and total lipid at 30 DAF to 2.1% and 11.2% at 100 DAF (Table 1). The phospholipid content, quantitated as lipid phosphorus, decreased with advancing maturity but increased temporarily at 60 DAF. Although the relative proportion of phospholipid and glycolipid of Anoka (30) differed from that of Bragg soybeans, the declining trend of these components of the two varieties was similar. The phospholipid content of Anoka seed decreased from 16.6% of the total lipid at 32 DAF to 3.8% at 60 DAF, but increased to 9.8% at 97 DAF. The glycolipid content of Anoka seed decreased from 8.3% of the total lipid at 32 DAF to 0.6% at 80 DAF, increasing to 1.6% at 97 DAF. The glycolipid content of Bragg seed

Table 1. Changes in lipid composition of Bragg soybean seed during development.^a

DAF ^b	Seed Dry Weight (mg)	Seed Lipids							
		Total Lipid (%)	Triglyceride		Steroids		Polar Lipid (%)	Phospho- lipid (%)	Glyco- lipid (%)
			(%)	mg/g (dry wt.)	(%)	(mg/seed)			
10	1.7	8.9	-	1.3	0.10(1.10)	2.2	-	1.3 (-)	
30	54.9	22.2	6.1(27.7)	0.6	0.06(0.25)	30.7	8.8	0.9(6.8)	7.3(33.2)
40	90.0	22.7	11.4(49.7)	0.4	0.04(0.15)	31.5	6.2	0.2(3.9)	5.2(23.2)
60	126.5	18.7	12.8(68.6)	0.3	0.03(0.18)	41.8	3.6	0.3(6.8)	2.4(11.7)
100	115.0	20.1	16.8(83.6)	0.3	0.03(0.16)	38.0	2.4	0.2(2.5)	1.9 (8.7)

^aUnless otherwise indicated, values for individual lipid classes and total lipids are calculated as percent of seed dry weight and percent of total lipid (parentheses) and have been adjusted (lipids isolated from TLC plates) to account for the 63.4% to 75.9% recovery at the different sampling times.

^bDAF = days after flowering.

decreased steadily from 33.2% of the total lipid to 8.7% over approximately the same time period, the most rapid decrease occurring between 30 and 60 DAF (Table 1). Both phospholipid and glycolipid were considered quantitatively minor components of the lipid of mature Bragg soybean.

Most studies of the lipid content of soybean seed during development have considered changes in fatty acid composition. In the very early stages of seed development (10 DAF) the oil is high in saturated fatty acids with C_{16} and C_{18} acids comprising ca 77% of the total (Table 2). However, between 10 and 30 DAF the relative proportion of saturated fatty acids declines very rapidly and subsequently unsaturated acids predominate with $C_{18:1}$ and $C_{18:2}$ acids comprising about 74% of the total. This shift in the degree of saturation suggests that the desaturase and fatty acid synthetase are not produced simultaneously in the early stages of seed development. Similar results have been reported for the Anoka (30), Horasay 63 (32), and other varieties, although results for the very early stages of development (10-24 DAF) for these cultivars have not been reported. After the change from predominantly saturated to unsaturated oil that occurred between 10 and 30 DAF, the relative proportions of most fatty acids remained almost constant to 100 DAF (Table 2). The exception of this was linoleic acid that increased from 48.4% of the total fatty acids at 30 DAF to 58.0% at 60 DAF and oleic acid that decreased from 26.2% to 18.8%. Although the relative proportions varied slightly, these results are similar to those for other varieties (12, 32), except that linolenic acid represented a larger portion of the total fatty acids in the early stages of development (24-40 DAF) in the other varieties that have been examined. Changes in the fatty acid composition of developing Bragg soybean seed have been studied previously and the results are similar to those obtained in this study except that the major decrease in the degree of saturation was not previously noted (29).

Table 2. Changes in the composition of major fatty acids from Bragg soybean seed during development.

DAF ^a	Total Fatty Acid (wt. %) ^b				
	C_{16}	C_{18}	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$
10	57.2	20.0	5.0	10.2	7.5
30	10.8	4.9	26.2	48.4	9.6
40	12.8	6.6	25.8	47.8	7.0
60	10.8	4.6	19.8	58.0	6.8
100	11.6	4.8	18.8	56.6	8.4

^aDAF = days after flowering.

^bLower relative amounts of C_{14} , $C_{15:1}$, C_{17} , and C_{20} were detected.

The major fatty acids of Bragg soybean seed collected at 100 DAF were C₁₆ (11.6%), C₁₈ (4.8%), C_{18:1} (18.8%), C_{18:2} (56.6%), and C_{18:3} (8.4%). The relative proportions of these acids are very similar to those previously reported for the Bragg variety and are in the range reported for other varieties studied: C₁₆ (9.7 to 12.7%), C₁₈ (2.7 to 4.9%), C_{18:1} (18.4 to 40.3%), C_{18:2} (40.5 to 58.9%) and C_{18:3} (3.4 to 8.9%) (8). Myristic (C₁₄) and eicosanoic (C₂₀) acids have been previously reported as components of soybean seed oil (17), but to our knowledge pentadecenoic (C_{15:1}) and heptadecanoic (C₁₇) acids have not been previously reported from this source (Table 2). Myristoleic (C_{14:1}), palmitoleic (C_{16:1}), docosanoic (C₂₂) and tetracosanoic (C₂₄) acids previously reported in some soybean varieties were not detected in the Bragg variety seed.

The free sterol content of Bragg soybean seed was very low. It decreased from 1.3 mg/g dry seed at 10 DAF to 0.33 mg at 100 DAF (Table 1). These results are similar to those obtained with the Tamanishiki variety (25), the principal decrease on a dry weight basis occurring between 10 and 30 DAF. However, the free sterol content per seed increased from 2.2 µg at 10 DAF to between 38.0 and 41.8 µg at 60 to 100 DAF (Table 1). Similar increases were obtained with developing corn kernels (10). Only free sterols have been analyzed in this study, but other forms such as fatty acid esters, glycosides, and acylated glycosides probably represented a relatively small proportion of the total sterols as described in previous reports where they comprised less than 40% of the total (25).

The free sterols were precipitated from the soybean seed oil as digitonides and analyzed by GLC-MS. The principal sterols of Bragg seed were stigmasterol (24-ethylcholesta-5,22-dienol), campesterol (24-methylcholest-5-enol), and sitosterol (24-ethylcholest-5-enol) in order of increasing relative proportions (Table 3) and are the major sterols of higher plant tissues (3) including seed oils (24). Cholesterol (cholest-5-enol) and stigmast-7-enol were also identified as minor 4-desmethyl sterol components of the Bragg seed oil. Each of the above sterols along with brassicasterol (24-methylcholesta-5,22-dienol), Δ^5 -avenasterol (24-ethylcholest-5-enol) and its Δ^7 isomer were detected in commercially prepared crude soybean vegetable oil (14, 22). Several 4,4-dimethyl and 4 α -methyl sterols were detected in the soybean vegetable oil (23, 26), but only one was detected in the Bragg seed oil, citrostadienol [ethylidenelophenol, 4-methyl-24-ethylcholesta-7,24(28)-dienol].

There were only minor changes in the relative proportions of individual sterols during seed development (Table 3) as was the case with developing corn kernels (10). The major sterol sitosterol decreased by ca 8% between 30 DAF and maturity and there was a corresponding increase in stigmasterol. Also, the relative amount of 24-ethylidenelophenol doubled over the 90 day sampling period, cholesterol decreased from 2.3% to 0.2%, and stigmast-7-enol increased from 4.8% to 7.4% between 60 and 100 DAF. These minor changes with time in the relative proportions of sterols probably have little physiological significance.

The alkane content of leaf and seed tissues of Bragg soybean was compared, but changes in hydrocarbon composition with seed development

Table 3. Changes in the relative proportions of sterols during the development of Bragg soybean seed.

DAF ^a	Total Free Sterols (%) ^b					
	I	II	III	IV	V	VI
10	1.7	12.3	14.4	61.3	4.0	1.3
30	1.8	15.2	14.0	63.1	4.4	1.5
40	1.1	13.8	15.6	64.6	3.6	1.2
60	2.3	15.2	20.1	54.2	4.8	3.4
100	0.2	12.8	21.0	56.0	7.4	2.6

^aDAF = days after flowering.

^bI = cholesterol, II = campesterol, III = stigmasterol, IV = sitosterol, V = stigmast-7-enol, VI = 24-ethylidenelophenol.

were not determined (Table 4). The alkanes of each tissue consisted of a homologous series ranging in chain length from C₁₉ to C₃₃ with odd numbered carbon chains predominant, and nonacosane (C₂₉) and hentriacontane (C₃₁) as the major homologues. This is typical of the leaf surface wax of most higher plants (36). The alkane content of the seed testa was about two times greater than that of leaf tissue and over seven times that of cotyledons (Table 4).

The seed alkane content of relatively few species has been reported. However, as in soybean, the hydrocarbon content of testa of *Plantago ovata* seed was much greater than that of cotyledons, although the relative proportions of homologues was similar between the two tissues (13). The alkane composition of the *P. ovata* seed was more complex than that of soybean, with both normal and methyl (*iso* and *anteiso*) branched chain alkanes and three distinct chain length ranges differing by absolute and relative proportions of component homologues and presence or the absence of branched chain alkanes. Hydrocarbons of the halophyte *Salicornia bigelovii* differed between the seed and shoot with the former containing branched isomers accompanying the normal alkanes (37). No branched chain alkanes were detected in Bragg soybean seed or leaf tissue. Except for C₃₁ (61.7%) in seed coat hydrocarbons, the predominance of odd over even chain homologues was not as pronounced as that found for alkanes from other species. Although C₃₁ (31.9%) was the principal alkane of cotyledon tissue, the relative proportion of homologues in this tissue more closely resembled that of soybean leaf wax than that of seed coat. In both the leaf wax and cotyledon tissue, there was a greater odd over even chain predominance of individual homologues than in the testa and C₂₉ represented a quantitatively more important component of the alkane fraction. Squalene was detected in the crude oil of hexane-extracted soybeans (17) and is a component of other important oil seed such as peanut (11), but was not detected in Bragg seed lipid.

Table 4. Alkane composition of Bragg soybean leaf and seed tissue.^a

Chain Length	Whole Seed	Seed Coat	Cotyledon	Leaf ^b
C ₁₉	1.5	0.6	5.1	0.1
C ₂₀	1.1	0.3	1.8	0.1
C ₂₁	0.8	0.2	1.7	0.2
C ₂₂	1.1	0.7	2.8	0.2
C ₂₃	1.0	1.1	3.6	3.5
C ₂₄	0.9	1.3	2.3	0.6
C ₂₅	1.0	1.7	4.4	4.1
C ₂₆	0.6	1.5	3.5	1.2
C ₂₇	2.6	3.2	8.8	10.0
C ₂₈	2.3	4.5	6.8	9.5
C ₂₉	8.6	6.6	12.7	21.2
C ₃₀	4.0	4.9	4.9	4.8
C ₃₁	65.1	61.7	31.9	39.5
C ₃₂	5.1	5.8	4.6	3.2
C ₃₃	5.4	6.0	5.1	2.0
µg/kg dry wt.	-	750	92	305

^aEach value represents the percent of the total alkanes.

^bAlkanes from surface wax of mature soybean leaves.

LITERATURE CITED

1. Alderks, O. H. 1949. The study of 20 varieties of soybeans with respect to quantity and quality of oil, isolated protein, and nutritional value for the mean. J. Amer. Oil Chem. Soc. 26:126-132.
2. Agrawal, P. K. and O. P. Vyas. 1971. Note on the effect of temperature on oil and protein content of the seed of 'Clark 63' soybean (*Glycine max* (L.) Merr.). Ind. J. Agric. Sci. 41:1122-1123.
3. Bean, G. 1973. Phytosterols. Adv. Lipid Res. 11:193-218.
4. Burrell, R. C. and A. C. Wolfe. 1940. A comparative study of the chemical composition of five varieties of soybeans. Food Res. 5: 108-113.

Lipids and Soybean Seed Development

5. Bush, P. B. and C. Grunwald. 1972. Sterol changes during germination of *Nicotiana tobacum* seeds. *Plant Physiol.* 50:69-72.
6. Chen, P. S., T. Y. Toribara, and H. Warner. 1956. Micro-determination of phosphorus. *Anal. Chem.* 28:1756-1758.
7. Chang, S. S., R. G. Krishnamurthy, and B. R. Reddy. 1967. The relationship between alkyl furans and the reversion flavor of soybean oil. *J. Amer. Oil Chem. Soc.* 44:159.
8. Chapman, G. W., J. A. Robertson, and D. Burdick. 1976. Chemical composition and lipoxygenase activity in soybeans as affected by genotype and environment. *J. Amer. Oil Chem. Soc.* 53:54-56.
9. Cowan, J. C. and C. D. Evans. 1962. Flavor reversion and related forms of oxidative deterioration. Pages 593-628 in *Autooxidation and antioxidants*, Vol. 11. (W. O. Lundberg, ed.) Interscience Publishers, Inc., New York.
10. Davis, D. L. and C. G. Poneleit. 1974. Sterol accumulation and composition in developing *Zea mays* L. kernels. *Plant Physiol.* 54:794-796.
11. Fedeli, E., G. Favini, F. Camurati, and G. Jacine. 1968. Regional differences in lipid composition in morphologically distinct fatty tissues: III Peanut seeds. *J. Amer. Oil Chem. Soc.* 45:676-679.
12. Felr, W. R., V. C. Thorne, and E. G. Hammond. 1971. Relationship of fatty acid formation and chlorophyll content in soybean seed. *Crop Sci.* 11:211-213.
13. Gelpi, E., H. Schnieder, V. M. Doctor, J. Tennison, and J. Oro. 1969. Gas chromatographic-mass spectrometric identifications of the hydrocarbons and fatty acids of *Plantago ovata* seeds. *Phytochemistry* 8:2077-2081.
14. Gutfinger, T. and A. Letan. 1974. Studies of unsaponifiables of several vegetable oils. *Lipids* 9:658-663.
15. Hansen, R. P. and Z. Czochanska. 1974. Composition of the lipids of lupin seed (*Lupinus angustifolius* L. var. "Uniwhite"). *J. Sci. Food Agric.* 25:409-415.
16. Hilditch, T. P. 1947. Pages 340-346 in *The chemical composition of natural fats*, 2nd ed. John Wiley and Sons, New York.
17. Hirayama, O. and K. Hujii. 1965. Glyceride structure and biosynthesis of natural fats. III. Biosynthetic process of triglycerides in maturing soybean seed. *Agric. Biol. Chem.* 29:1-6.
18. Hirota, T., S. Gota, M. Katayama, and S. Funahashi. 1974. Fractional analyses of soybean sterols in four classes. *Agric. Biol. Chem.* 38:1539-1540.

19. Hitchcock, C. and B. W. Nichols. 1971. Plant lipid biochemistry. Academic Press, New York. 387 pp.
20. Howell, R. W. and J. L. Cartter. 1953. Physiological factors affecting composition of soybeans. I. Correlation of temperature during certain portions of the pod filling stage with oil percentage in mature beans. *Agron. J.* 45:526-528.
21. Idler, D. R. and C. A. Baumann. 1953. Skin sterols: Sterol structure and the Liebermann-Burchard reaction. *J. Biol. Chem.* 203:389-396.
22. Itoh, T., T. Tamura, and T. Matsumoto. 1973. Sterol composition of 19 vegetable oils. *J. Amer. Oil Chem. Soc.* 50:122-125.
23. Itoh, T., T. Tamura, and T. Matsumoto. 1973. Methylsterol composition of 19 vegetable oils. *J. Amer. Oil Chem. Soc.* 50:300-303.
24. Jeong, T. M., T. Itoh, T. Tamura, and T. Matsumoto. 1974. Analysis of sterol fractions from twenty vegetable oils. *Lipids* 9:921-927.
25. Katayama, J. and M. Katoh. 1973. Accumulation of sterols in free form, fatty acid esters, acylated glucosides and non-acylated glucosides. *Plant and Cell Physiol.* 14:681-688.
26. Kleinzeller, A. 1947. in *Advances in enzymology*, Vol. B. Interscience Publishers, Inc., New York.
27. Kulesh, Y. G. and A. M. Chernitsyn. 1971. Pulsed nuclear magnetic resonance method for determination of humidity and oil content of oily seeds. *Sov. Plant Physiol.* 18:881-883.
28. Metcalfe, L. D. and A. A. Schmitz. 1961. The rapid preparation of fatty acid esters for gas chromatographic analysis. *Anal. Chem.* 33:363-364.
29. Narayan, R. and A. C. Joshi. 1971. Developmental changes in fatty acid composition of soybean seeds. *Ind. J. Biochem. Biophys.* 8:62-63.
30. Privett, O. S., K. A. Kougherty, W. L. Grdahl, and A. Stolyhwo. 1973. Studies on the lipid composition of developing soybeans. *J. Amer. Oil Chem. Soc.* 50:516-520.
31. Roehm, J. N. and O. S. Privett. 1970. Changes in the structure of soybean triglycerides during maturation. *Lipids* 5:353-358.
32. Rubel, A., R. W. Rinne, and D. T. Canvin. 1972. Protein, oil, and fatty acids in developing soybean seeds. *Crop Sci.* 12:739-741.
33. Simmons, R. O. and F. W. Quackenbush. 1954. The sequence of formation of fatty acids in developing soybeans. *J. Amer. Oil Chem. Soc.* 31:441-443.

Lipids and Soybean Seed Development

34. Simmons, R. O. and F. W. Quackenbush. 1954. Comparative rates of formation of fatty acids in the soybean seed during development. *J. Amer. Oil Chem. Soc.* 31:601-603.
35. Smouse, T. H. and S. S. Chang. 1967. A systematic characterization of the reversion flavor of soybean oil. *J. Amer. Oil Chem. Soc.* 44:509-514.
36. Tulloch, A. P. 1976. Chemistry of waxes of higher plants. Pages 236-289 in *Chemistry and biochemistry of plant waxes*. (P. E. Kolattukudy, ed.) Elsevier, Amsterdam.
37. Weete, J. D., W. G. Rivers, and D. J. Weber. 1971. Hydrocarbon and fatty acid distribution in the halophyte, *Salicornia bigelovii*. *Phytochemistry* 9:2041-2045.
38. Wilson, R. F. and R. W. Rinne. 1974. Phospholipids in the developing soybean seed. *Plant Physiol.* 54:744-747.

REDESCRIPTION OF *Echiniscus virginicus* RIGGIN
(TARDIGRADA) WITH NOTES ON LIFE HISTORY,
RANGE, AND GEOGRAPHIC VARIATION¹

D. Christenberry and W. H. Mason
Department of Zoology-Entomology
Auburn University, Auburn, AL 36830

Abstract. *Echiniscus virginicus* Riggin 1962 was redescribed on the basis of a reassessment of the holotype, and additional specimens which include previously unknown stages of its life history. The range of the species is extended from its type locality in Virginia to include localities in Georgia, Alabama, Tennessee, and the Galápagos Islands. Geographic variability is noted.

INTRODUCTION

Tardigrades are animals which range in size from about 100 μ m to 1.5mm in length. Even though they are smaller than some protozoans, they exhibit some degree of segmentation, a complete gut, distinct muscles, and a nervous system. Eyes may be present or absent. Their four pairs of legs are generally unjointed and equipped with claws. They were for many years classified among the arthropods but are currently considered to constitute a phylum, Tardigrada, which was probably derived somewhere along the Onychophora-Myriapoda line of evolution.

Tardigrades or "water bears" feed on a number of different substrates. Many feed on vegetation and may be seen to pierce plant cells with stylets, projected from the mouth tube. They then pump the contents of the cells into their bodies by the action of a muscular, tripartite pharynx. Other tardigrades may ingest whole, though relatively small organisms, such as nematodes, rotifers, and other tardigrades. We have in our collection one specimen containing the remains of four rotifers and three water bears.

Environments which prove hostile to many animals are often quite suitable to tardigrades. They are, for instance, numerous on such dry, sun-baked surfaces as that of Bald Rock, a large schist outcrop north of Wadley, Alabama. Their survival in this and other such environments depends upon their ability to assume a resistant state of dormancy referred to as cryptobiosis or anhydrobiosis. Animals entering this state shrivel and shorten to form a barrel-shaped structure called a tun which is relatively devoid of water (Crowe & Madin 1974). The tuns exhibit virtually undetectable metabolic activity and may endure conditions adverse to active life for many years.

Redescription of *Echiniscus virginicus*

Some species appear to be cosmopolitan, while others appear to be restricted to very specific habitats. Wind is probably the most important dispersing agent, though other agents such as insects and water currents are also undoubtedly involved (Ramazzotti 1972). The animals' ability to assume cryptobiotic and cystic states in which they may lie dormant and quite resistant for long periods of time facilitates dispersal, as does the minute size and pollen-like shape of many eggs.

Within the Order Heterotardigrada, the family Echiniscidae is characterized by a parthenogenic mode of reproduction (Pennak 1953) and a dorsal cuticular armor of plates, often equipped with spines, as shown in Figures 1-3. The majority of species in Echiniscidae are placed in the genus *Echiniscus* and are distinguished from one another primarily on the basis of the cuticular pattern on the plates and the number, distribution, and shape of the spines and cirri attached to the plates. Designations for plates, spines, and cirri of *E. (Echiniscus) virginicus* Riggin 1962, the subject of this study, are given in Figure 4.

Echiniscus virginicus was originally described on the basis of three specimens. Neither the written characterization nor the illustrations provide adequate information concerning the cirri, spines, cuticular texture, pattern of ridges, or subdivision of plates.

In 1976 and 1977, the senior author collected numerous specimens of a tardigrade resembling written descriptions of both *E. virginicus* and *E. quadrispinosus* Richters 1902. An attempt was made to determine the identity of the animals. Specimens were sent to Dr. G. T. Riggin who identified them as *E. virginicus*. One of these specimens and others of the same series were sent to Dr. G. Ramazzotti, who compared them to specimens of *E. quadrispinosus* and determined that *E. virginicus*, previously considered by Ramazzotti (1972) to be a *nomen dubium*, is in fact a species.

Examination of the holotype allows it to be accurately described for the first time. In addition, a collection of a series of over 200 specimens provides information concerning previously unknown stages of the life history. Geographic variation is determined on the basis of the authors' collection. Range extensions are determined on the basis of our collection and specimens from series collected by other tardigradologists.

MATERIALS AND METHODS

Approximately 600 samples of mosses, lichens, and liverworts were collected from various localities in North Carolina, Georgia, Alabama, and Florida between August, 1976 and December, 1977. In the laboratory these samples were inverted in petri dishes and covered with tap water. Samples were soaked, with occasional agitation, for 2-3 hours. Substrate was removed and dishes were scanned with a binocular microscope at a power of 20-30X. Tardigrades were removed with a micropipette to a small stendorf dish of clean water and subsequently transferred to a drop of Turttox CMC-10 mounting medium or to a modified Hoyer's medium on a #1, 25mm square coverslip. This preparation was covered with a

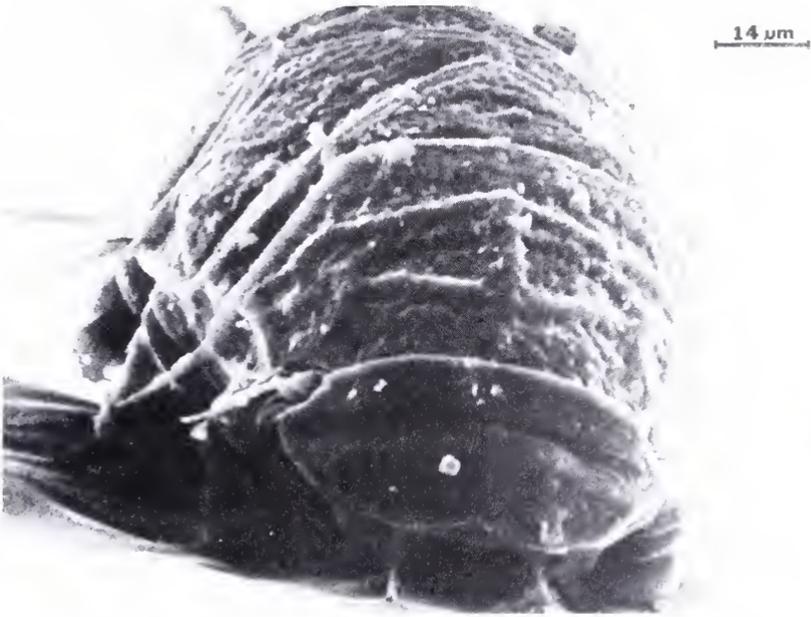


Figure 1. Scanning micrograph. *Echiniscus virginicus*, adult, frontal view.



Figure 2. Scanning micrograph. *Echiniscus virginicus*, adult, lateral view.

Redescription of *Echiniscus virginicus*

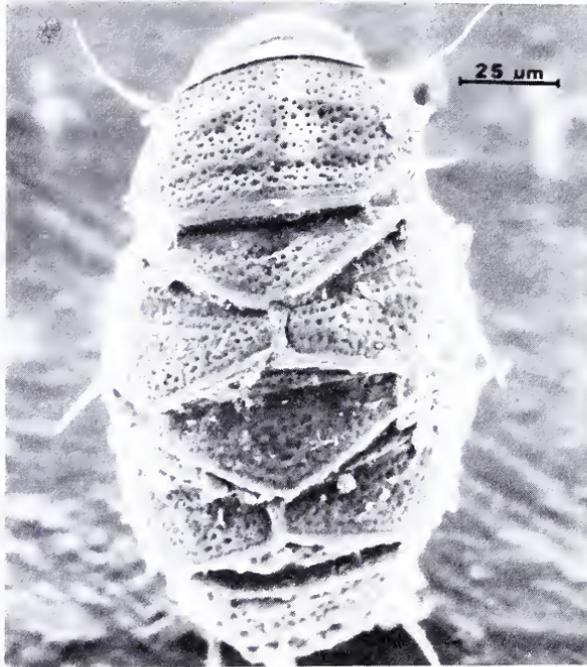


Figure 3. Scanning micrograph. *Echiniscus virginicus*, adult, dorsal view.

#0, 12mm circular coverslip. Coverslips containing individually mounted specimens were placed in Cobb aluminum slide frames, allowed to dry 3 weeks, and then ringed with Murrayite.

Formulation of the modified Hoyer's was as follows: 50ml distilled water, 30g gum arabic, 126g chloral hydrate, 20g glycerine, 1g I₂KI, and 2g I₂. The ingredients were mixed in the above sequence and filtered, under vacuum aspiration, through a No. 2 Whatman filter. This medium is most desirable for long-term preservation as the I₂KI and I₂ inhibit crystal formation and impart a faint coloration to the cuticle. The reduction in chloral hydrate also diminishes the tendency of the medium to crystallize.

Illustrations (Figs. 5-7) were drawn from observations made using the oil immersion objective of a phase contrast microscope and a drawing tube. All features are drawn to scale, although drawings are composites of several specimens presenting different aspects.

Preparation for scanning electron microscopy was as follows: Specimens, killed with boiling water, were placed inside water-filled lens paper molded to the inner wall of a thoroughly performed BEEM capsule.

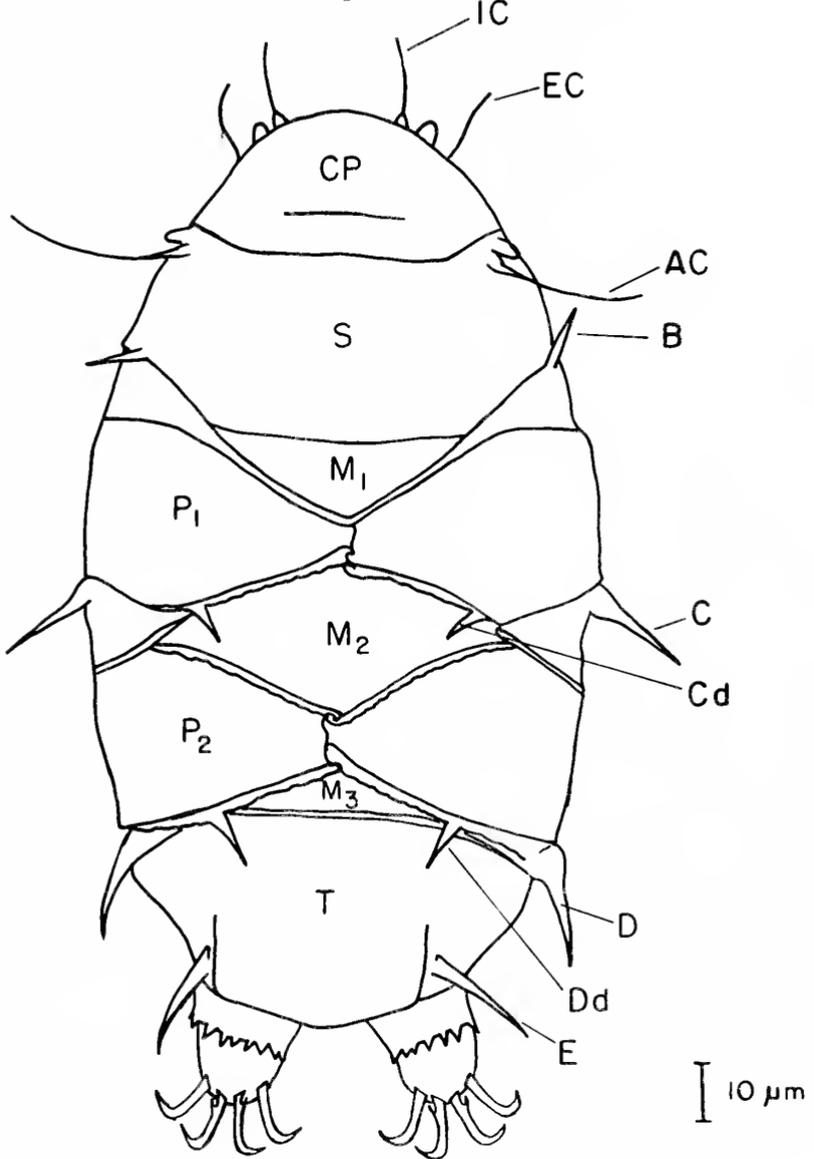


Figure 4. *Echiniscus virginicus*' structures of taxonomic importance. *Cirri*: IC, internal buccal cirrus; EC, external buccal cirrus; AC, cirrus A. *Spines*: Upper case letters B-E indicate longitudinal positions of spines. Lower case letter d indicates transverse position (dorsal) of spines. *Cuticular Plates*: CP, cephalic plate; S, scapular plate; M₁, 1st medial plate; P₁, 1st paired plate; M₂, 2nd medial plate; P₂, second paired plate; M₃, 3rd medial plate; T, terminal plate.

Redescription of *Echiniscus virginicus*

The lens paper extending beyond the lip of the capsule was folded shut and the lid was closed. The capsule was placed in a 20ml vial of 10% alcohol and allowed to equilibrate 20 minutes. It was subsequently passed through a series of vials containing 20%-100% alcohol, with concentrations increasing in 10% increments. Twenty minutes were allowed at each step for equilibration. The capsule was removed from 100% alcohol to a 20ml vial of amyl acetate and allowed to equilibrate for 45 minutes. The capsule and its contents were then dried with CO₂ in a Denton CEP-1 Critical Point Drying Apparatus. A gold-palladium coating of approximately 350 Å was evaporated onto the specimens in a Denton DV-502 vacuum evaporator. Observations were made with an AMR 1000 scanning electron microscope.

In the following redescription, young (sometimes referred to as larvae) are presumed first instars, subadults are morphologically immature forms which may be reproductively mature, and adults are morphologically and reproductively mature individuals.

Data in the redescription represent mean lengths or ranges unless otherwise indicated. As a further aid to identification of *E. virginicus*, Table I summarizes morphological measurements and provides such additional information as number of specimens measured, standard errors of the means, standard deviations, and ranges.

REDESCRIPTION

Echiniscus virginicus Riggin 1962

Diagnosis: Body length 90µm-192µm; adults with spines B, C, Cd, D, Dd, and E; subadults with spines C, Cd, D, Dd, and E; young with spine E only; cuticular pores of subadults and adults 0.5-2.5µm in diameter, and irregular in both shape and distribution. Posterior edges of paired plates and 1st and 2nd medial plates exhibit irregular thickenings. Cirrus A 22-35.5µm in subadults and adults.

Redescription: Holotype (USNM 30420), large adult specimen, color yellow, body 186µm, internal buccal cirrus 15µm, external buccal cirrus 15µm, cirrus A 34µm, spine B 5µm, spine C 16µm, spine Cd 6µm, spine D 22µm, spine Dd 16µm, spine E 28µm, claws 14.4µm.

Young (Fig. 5A), body 92.3µm, body color yellow, internal buccal cirrus 7.3µm, external buccal cirrus 7.3µm, cirrus A 17.8µm, spine E 10.3µm, cuticle with superficial pores 0.8µm or less in diameter at edge of dorsal plates, underlying (lower focal plane) reticulate pattern (Fig. 5B) present. Each leg of 4th pair exhibits a lateral papilla and dentate collar with approximately 6 teeth, ventrally directed spur present on 1st pair of legs, 2 claws each 5.4µm with ventrally directed hooks present on each leg.

Subadults (Fig. 6), body 148µm, body color yellow, internal buccal cirrus 12.9µm, external buccal cirrus 13.2µm, cirrus A 28.6µm, spine B absent, spine C 14.9µm, spine Cd 3.6µm, spine D 15.0µm, spine Dd 9.4µm, spine E 16.8µm, irregularly shaped superficial pores 0.5-2.5µm in widest

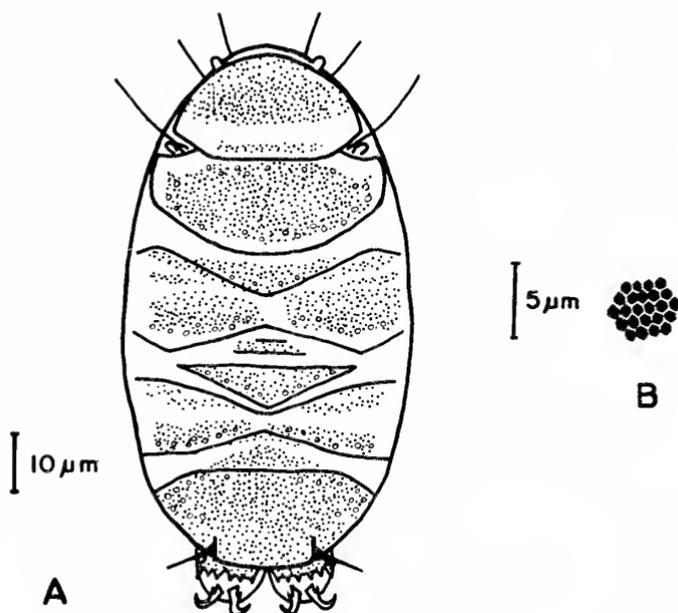


Figure 5. A. *Echiniscus virginicus*, young (presumed 1st instar). B. Reticulate pattern characteristic of underlying cuticular layer.

diameter, especially well pronounced on thickened caudal portions of paired plates and medial plates 1 and 2, underlying reticulate pattern present. Plates subdivided by ridges and invaginations. Posterior borders of paired plates and 1st and 2nd medial plates with irregularly thickened margins. Each leg of 4th pair exhibits a lateral papilla and dentate collar with 8-10 teeth, ventrally directed spur present on first pair of legs, claws $9.3\mu\text{m}$, medial claws each with ventrally directed hook.

Adults (Fig. 7), body $166.5\mu\text{m}$, body color yellow, internal buccal cirrus $14.3\mu\text{m}$, external buccal cirrus $14.7\mu\text{m}$, cirrus A $28.9\mu\text{m}$, spine B $9.9\mu\text{m}$, spine C $16.8\mu\text{m}$, spine Cd $3.9\mu\text{m}$, spine D $16.7\mu\text{m}$, spine Dd $12.1\mu\text{m}$, spine E $17.2\mu\text{m}$, cuticular plates same as those of subadult, each leg of 4th pair exhibits a lateral papilla and dentate collar with 8-12 teeth, ventrally directed spur present on first pair of legs, claws $11.0\mu\text{m}$, medial claws each with ventrally directed hook.

Eggs of $55\mu\text{m}$ deposited in exuviae of subadults and adults.

Material Studied: Holotype. Four exuviae containing eggs, 4 young, 201 subadults and adults (collected from Alabama, Florida, and Georgia). One specimen from the Galápagos Islands (Santa Cruz Island) was examined,

Redescription of *Echiniscus virginicus*

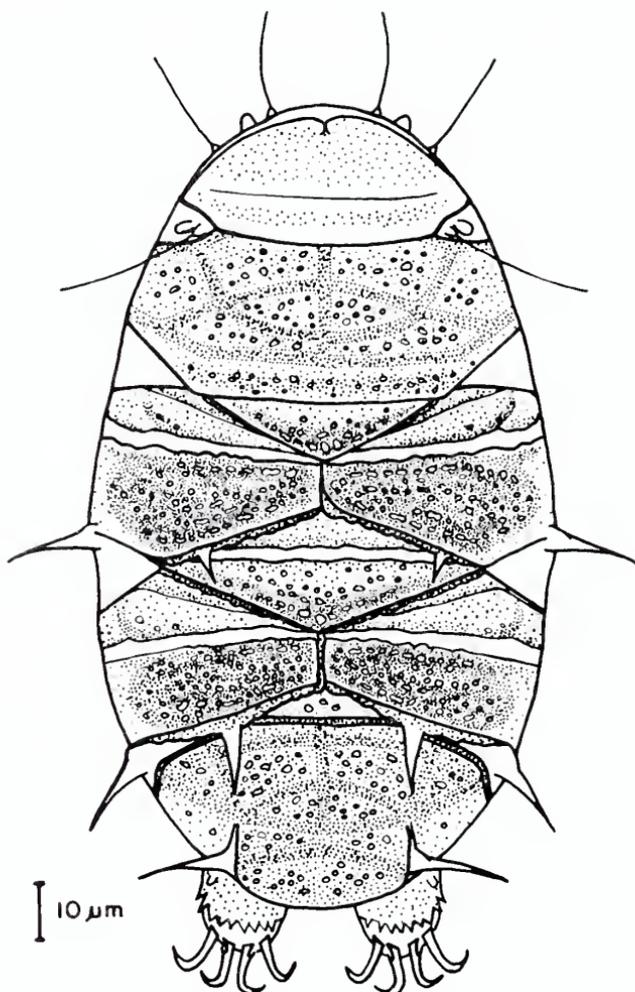


Figure 6. *Echiniscus virginicus*, subadult. Unshaded areas on plates represent recessed areas. Shaded areas represent ridges.

as was one specimen from Roan Mountain, Tennessee. Means and ranges of measurements were determined from measurements of 3 young, 25 subadults, and 33 adults (Table I). Representative samples of the author's collection have been deposited at the National Museum of Natural History, Smithsonian Institution, Washington, D.C. and in the collections of Drs. G. Pilato and M. G. Binda at the Instituto Policattedra di Biologia Animale, Università di Catania, Catania, Italy; Dr. G. Ramazzotti, Milan, Italy; Dr. W. Maucci, Trieste, Italy; and Dr. Carlo Robotti, Torino, Italy. The remainder of the collection is in the possession of the authors.

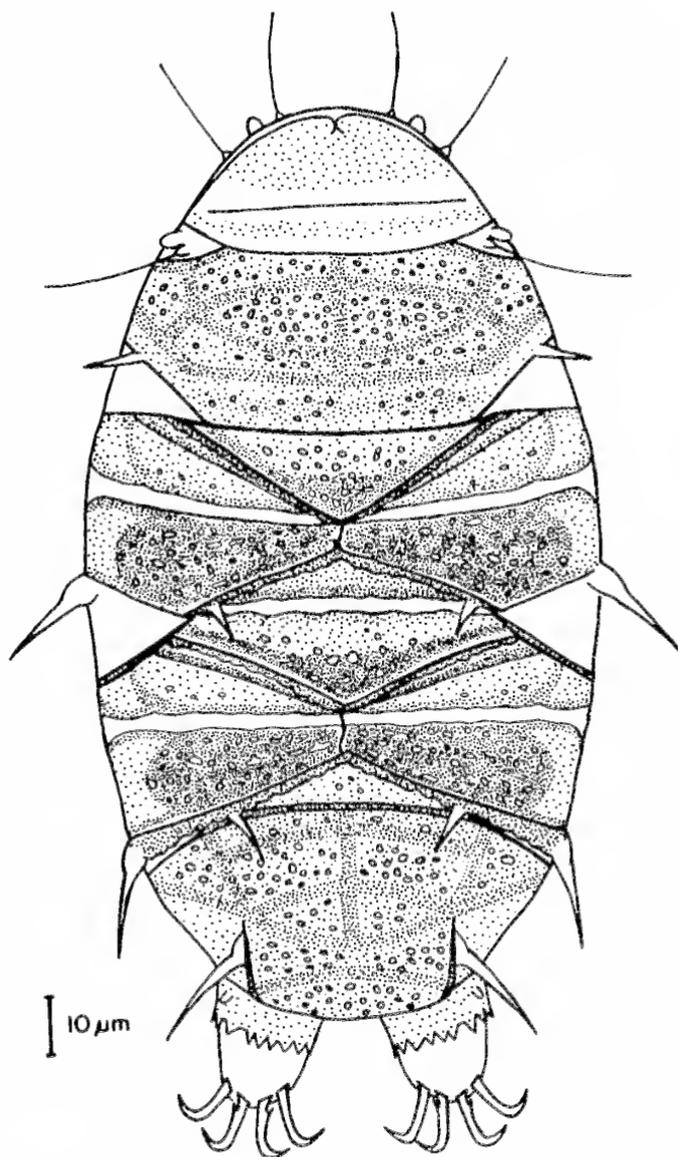


Figure 7. *Echiniscus virginicus*, adult. Unshaded areas represent recessed areas. Shaded areas represent ridges.

Redescription of *Echiniscus virginicus*

Table I. Summary of morphometric data (in μm) for *Echiniscus virginicus*.

Morphological Class	Character	Number of Measurements	Mean	Standard Error	Standard Deviation	Range
Young	Body Length	3	92.3	1.5	3.2	91.0-96.0
	Internal Cirrus	3	7.3	0.1	0.3	7.0-7.5
	External Cirrus	3	7.3	0.1	0.3	7.0-7.5
	A Cirrus	3	17.8	0.6	1.4	17.0-19.5
	E Spine	3	10.3	0.3	0.6	10.0-11.0
	Claws (4th Leg)	3	5.4	0.0	0.0	5.4-5.4
	Body Length	25	148.1	3.0	4.8	12.0-165.0
	Internal Cirrus	16	12.9	0.4	1.5	10.5-14.5
	External Cirrus	17	13.2	0.4	1.7	11.0-16.0
	A Cirrus	17	28.6	1.1	4.6	22.0-35.5
Subadults	C Spine	25	14.9	0.8	4.2	5.5-21.0
	Cd Spine	25	3.6	0.3	1.3	1.5-5.5
	D Spine	25	15.0	0.7	3.5	8.5-21.5
	Dd Spine	25	9.4	1.0	4.9	1.5-17.5
	E Spine	25	16.8	0.7	3.4	12.0-24.5
	Claws (4th Leg)	17	9.3	0.1	0.6	8.0-11.0
	Buccal Papilla	17	5.2	0.1	0.5	4.0-6.0
	Cephalic Papilla	17	4.2	0.2	0.9	2.5-6.0
	Papilla 4th Leg	17	2.9	0.1	0.3	2.5-3.5
	Body Length	33	166.5	2.6	5.1	122.0-192.0
Adults	Internal Cirrus	16	14.3	0.3	1.2	11.0-16.5
	External Cirrus	16	14.7	0.3	1.2	12.0-17.0
	A Cirrus	16	28.9	0.8	3.0	23.0-33.5
	B Spine	33	9.9	0.5	3.0	2.5-15.0
	C Spine	30	16.8	0.5	2.8	10.5-22.5
	Cd Spine	33	3.9	0.2	0.9	2.5-5.5
	D Spine	32	16.7	0.4	2.4	11.5-21.5
	Dd Spine	33	12.1	0.8	4.5	3.5-18.5
	E Spine	33	17.2	0.5	2.7	13.0-22.5
	Claws (4th Leg)	16	11.0	0.6	2.6	8.0-15.0
Buccal Papilla	16	5.6	0.1	0.6	4.0-6.5	
Cephalic Papilla	16	4.4	0.2	0.7	3.5-6.0	
Papilla 4th Leg	15	3.1	0.1	0.4	2.5-3.5	

Locality Data: *Echiniscus virginicus* has been found to be abundant in all samples of the leafy liverwort, *Lejeunea patens* Lindb. growing on *Quercus* in Alabama counties of Baldwin, Lee, and Tallapoosa and in Walton County, Florida. It has been found in low numbers in a few samples of the lichen *Parmelia*, collected in Lee County, Alabama and Hall County, Georgia. Diane R. Nelson (pers. comm.) reports collection from the Tennessee counties of Mitchell, Carter, and Montgomery. Robert O. Schuster and A. A. Grigarick (pers. comm.) report the collection of 10 specimens from the Galápagos Islands. [Due to inadequacies of the literature these animals were initially reported as *E. quadrispinosus* (Nelson 1974; Schuster & Grigarick 1966).] These reports constitute range extensions beyond the type locality of Virginia.

Remarks: While the total number of molts characterizing the development of members of this species is not known, we have determined that when animals are classed solely on the basis of spine distribution, the mean body lengths of these three groups vary significantly ($P < .01$). These means are reported in Table I.

One cuticle containing eggs and two young were collected in October, 1976 from Escambia County, Alabama. Three cuticles containing eggs and two young were collected in October, 1977 from Tallapoosa County, Alabama. These were the only times that eggs and a full range of morphological forms were found within the same substrate samples, and suggest a reproductive peak at or near this season. Collections made in July, August, September, January, and March contained only subadults and adults.

Exuviae of subadults as well as adults have been found containing eggs. It is therefore assumed that at least the older individuals in the subadult class are reproductively mature, as are the members of the adult class.

Table II correlates, pair-by-pair, the previously discussed morphological characters of subadults and adults. Data used here were compiled using samples of three populations collected from *Lejeunea patens* Lindb. Each locality, Baldwin and Tallapoosa counties in Alabama and Walton County, Florida, was separated from the others by 150 miles or more. Population samples from Baldwin and Tallapoosa counties were taken in the month of October, during reproductive phases of the life cycle. The Florida specimens were collected during August. All character measurements except B, Cd, and Dd spine lengths, and claw lengths correlate positively and significantly ($P < .05$) with all other measurements. This suggests that B, Cd, and Dd spine lengths, and claw lengths are either quite variable within populations, among populations, or both.

Analysis of variance of the population sample means show that B spine and claw length measurements do not vary significantly among the three adult populations, but that the lengths of the Cd and Dd spines do ($P < .001$). Thus the B spine and claw lengths are highly variable within a given population and cannot be used to distinguish populations. However, the significant difference in relative lengths of the Cd and Dd spines suggests that these characters may be useful in distinguishing

Redescription of *Echiniscus virginicus*

Table II. Comparison of selected morphological features¹ of *Echiniscus virginicus*.

	BL	IC	EC	AC	B	C	Cd
BL	1.000 <.05 58	0.692 <.05 32	0.663 <.05 33	0.363 <.05 33	0.391 <.05 33	0.615 <.05 58	0.467 <.05 55
IC	0.692 <.05 32	1.000 <.05 32	0.941 <.05 32	0.629 <.05 32	0.477 >.05 16	0.664 <.05 32	0.228 >.05 32
EC	0.663 <.05 33	0.941 <.05 32	1.000 <.05 33	0.603 <.05 33	0.562 <.05 16	0.619 <.05 33	0.310 >.05 33
AC	0.363 <.05 33	0.629 <.05 32	0.603 <.05 33	1.000 <.05 33	-0.011 >.05 16	0.722 <.05 33	0.166 >.05 33
B	0.391 <.05 33	0.477 >.05 16	0.562 <.05 16	-0.012 >.05 16	1.000 <.05 33	-0.028 >.05 33	-0.067 >.05 30
C	0.615 <.05 58	0.664 <.05 32	0.619 <.05 33	0.722 <.05 33	-0.284 >.05 33	1.000 <.05 58	0.463 <.05 55
Cd	0.467 <.05 55	0.228 >.05 32	0.310 >.05 33	0.166 >.05 33	-0.067 >.05 30	0.463 <.05 55	1.000 <.05 55
D	0.633 <.05 58	0.711 <.05 32	0.697 <.05 33	0.660 <.05 33	0.030 >.05 33	0.857 <.05 58	0.529 <.05 55
Dd	0.259 >.05 57	0.129 >.05 32	0.126 >.05 33	-0.336 >.05 33	0.406 <.05 32	0.151 >.05 57	0.425 <.05 55
E	0.401 <.05 58	0.555 <.05 32	0.504 <.05 33	0.735 <.05 33	-0.060 >.05 33	0.783 <.05 58	0.249 >.05 55
CL	0.443 <.05 33	0.439 <.05 32	0.451 <.05 33	0.172 >.05 33	0.433 >.05 16	0.169 >.05 33	0.028 >.05 33
BP	0.683 <.05 33	0.594 <.05 32	0.550 <.05 33	0.377 <.05 33	0.408 >.05 16	0.593 <.05 33	0.327 >.05 33
CP	0.605 <.05 33	0.586 <.05 32	0.602 <.05 33	0.499 <.05 33	0.093 >.05 16	0.729 <.05 33	0.354 <.05 33
LP	0.582 <.05 32	0.667 <.05 31	0.612 <.05 32	0.429 <.05 32	0.402 >.05 15	0.559 <.05 32	0.325 >.05 32

¹BL, body length; IC, internal cirrus; EC, external cirrus; AC, A cirrus; B, B spine; C, C spine, Cd, dorsal C spine; D, D spine; Dd, dorsal D spine; E, E spine; CL, claw; BP, buccal papilla; CP, cephalic papilla;

D. Christenberry and W. H. Mason

Table II. continued

D	Dd	E	CL	BP	CP	LP
0.633 <.05 58	0.259 >.05 57	0.401 <.05 58	0.443 <.05 33	0.683 <.05 33	0.605 <.05 32	0.582 <.05 32
0.712 <.05 32	0.129 >.05 32	0.555 <.05 32	0.439 <.05 32	0.594 <.05 32	0.586 <.05 32	0.667 <.05 31
0.697 <.05 33	0.126 >.05 33	0.504 <.05 33	0.451 <.05 33	0.550 <.05 33	0.602 <.05 33	0.612 <.05 32
0.660 <.05 33	-0.336 >.05 33	0.735 <.05 33	0.172 >.05 33	0.377 <.05 33	0.499 <.05 33	0.429 <.05 32
0.030 >.05 33	0.406 <.05 32	-0.060 >.05 33	0.434 >.05 16	0.408 >.05 16	0.093 >.05 16	0.402 >.05 15
0.857 <.05 58	0.151 >.05 57	0.783 <.05 58	0.169 >.04 33	0.593 <.05 33	0.729 <.05 33	0.559 <.05 32
0.529 <.05 55	0.425 <.05 55	0.249 >.05 55	0.028 >.05 33	0.327 >.05 33	0.354 <.05 33	0.325 >.05 32
1.000 <.05 58	0.270 <.05 57	0.658 <.05 58	0.270 >.05 33	0.551 <.05 33	0.717 <.05 33	0.646 <.05 32
0.270 <.05 57	1.000 <.05 57	-0.135 >.05 57	0.191 >.05 33	0.089 >.05 33	0.094 >.05 33	0.224 >.05 32
0.658 <.05 58	-0.135 >.05 57	1.000 <.05 58	-0.027 >.05 33	0.446 <.05 33	0.564 <.05 33	0.561 <.05 32
0.269 >.05 33	0.191 >.05 33	-0.027 >.05 33	1.000 <.05 33	0.428 <.05 33	0.184 >.05 33	0.169 >.05 32
0.551 <.05 33	0.089 >.05 33	0.446 <.05 33	0.428 <.05 33	1.000 <.05 33	0.365 <.05 33	0.588 <.05 16
0.717 <.05 33	0.094 >.05 33	0.564 <.05 33	0.184 >.05 33	0.365 <.05 33	1.000 <.05 33	0.643 <.05 32
0.646 <.05 32	0.224 >.05 32	0.561 <.05 32	0.169 >.05 32	0.588 <.05 32	0.643 <.05 32	1.000 <.05 32

LP, leg papilla. The first value in each grouping of three is the r value, the second is the r value probability, and the third is the number of character pairs.

Redescription of *Echiniscus virginicus*

between the adults of populations from different localities. This supposition is reinforced by the fact that the greatest difference in mean Cd and Dd spine lengths occurs between the adults from Baldwin and Tallapoosa counties. These samples were both taken in October, during a reproductive phase of the life cycle, thus minimizing the possible effects of seasonal variation. The means of other morphometric data did not vary significantly among these samples of adults.

In the subadults, the Cd spine lengths do not vary significantly among population samples, suggesting that locality differences in this character are attained in later stages of development. The Dd spines of the subadults do vary ($P < .01$) among population samples. The greatest difference between means is again between those of the samples from Baldwin and Tallapoosa counties. These data indicate that difference in Dd spine lengths between populations develops earlier than does variability in Cd spine lengths. The E spines also vary among population samples of subadults ($P < .01$). This seems to indicate differential rates of development for this character in populations at various localities.

It is interesting to note that Schuster (1966) collected *E. virginicus*, *E. cavagnaroi*, and *E. kofordi* from the Galápagos Islands. Christenberry (in press) has since collected these same three species from the banks of Silas Creek in Escambia County, Alabama. These species may thus share similar habitat preferences or requirements.

The confusion concerning the status of *E. virginicus* cannot be attributed solely to inadequacies in its original description. Erroneous identification of this species must also be attributed to inadequacies of the description of *E. quadrispinosus* Richters, 1902 and its varieties. *Echiniscus quadrispinosus* has a cuticle with a superficial pattern of pores and an underlying reticulate pattern as well as a spine distribution similar to that of *E. virginicus*. The importance of the double cuticular pattern and spine distribution have overshadowed the importance of variability in reticulate patterns; in the shape, size, and distribution of pores; in cirri and spine lengths; in cuticular thickenings (including ridges); and in the morphology of the plate margins. Until these kinds of data are included in a redescription of *E. quadrispinosus*, the *E. quadrispinosus* complex will remain in large part what Horning et al. (1978) refer to as "a systematic shambles."

ACKNOWLEDGMENTS

I wish to express appreciation to Dr. Diane R. Nelson for allowing me to use a photomicrograph (Fig. 3) obtained through her studies of tardigrades in Tennessee, U.S.A., to Robert O. Schuster, Principal Museum Scientist, University of California at Davis for allowing me to examine specimens from that institution's excellent collection, and conclusively to Dr. Robert P. Higgins, Curator, Department of Invertebrate Zoology, Smithsonian Institution for his valuable direction in this project and for supplying data concerning type material.

LITERATURE CITED

- Christenberry, D. 1979. *Echiniscus kofordi* and *E. cavagnaroi* (Tardigrada) occurring outside of type localities. Transactions of the American Microscopical Society. In press.
- Crowe, J. H. and K. A. Madin. 1974. Anhydrobiosis in tardigrades and nematodes. Transactions of the American Microscopical Society 93: 513-523.
- Horning, D. S., R. O. Schuster and A. A. Grigarick. 1978. Tardigrada of New Zealand. New Zealand Journal of Zoology 5:185-280.
- Nelson, D. R. 1975. Ecological distribution of tardigrades on Roan Mountain, Tennessee-North Carolina. Memorie dell' Instituto Italiano di Idrobiologia 32(suppl.):225-276.
- Pennak, R. W. 1953. Freshwater invertebrates of the United States. Ronald Press, New York. pp. 240-255.
- Ramazzotti, G. 1972. II Phylum Tardigrada, Seconda Edizione Aggiornata. Memorie dell' Instituto Italiano di Idrobiologia 28:1-732.
- Richters, F. 1902. Neue Mossbewohner. Senckenbergische Naturforschende Gesellschaft, Frankfurt a.M. pp. 23-26.
- Riggin, G. T. 1962. Tardigrada of southwest Virginia; with the addition of a description of a new marine species from Florida. Virginia Agricultural Experiment Station Technical Bulletin 152:1-145.
- Schuster, R. O. and A. A. Grigarick. 1966. Tardigrades from the Galápagos and Cocos Islands. Proceedings of the California Academy of Sciences, Vol. XXXIV, No. 5, pp. 315-328.

NOTES

THE JOURNAL
OF THE
ALABAMA ACADEMY
OF SCIENCE

AFFILIATED WITH THE
AMERICAN ASSOCIATION FOR THE
ADVANCEMENT OF SCIENCE

VOLUME 50

APRIL, 1979

NO. 2

EDITOR:

W. H. Mason, General Biology, Auburn University, Auburn, AL 36830

ARCHIVIST:

R. G. Eaves, Department of History, Auburn University, Auburn AL 36830

EDITORIAL BOARD:

R. T. Gudauskas, Chairman, Department of Botany and Microbiology, Auburn University, Auburn, AL 36830

E. A. Curl, Department of Botany and Microbiology, Auburn University, Auburn, AL 36830

W. W. Paulder, Department of Chemistry, University of Alabama, University, AL 35486

ADVISORY BOARD:

W. L. Alford, Auburn University

Walker H. Land, Jr., IBM

Charles Baugh, Univ. South Alabama

H. S. Marks, N.E. St. Jr. Col.

G. F. Brockman, Univ. Ala., B'ham

M. Miller, Univ. South Alabama

R. J. Fornaro, Univ. South Alabama

W. W. Paulder, UA, Tuscaloosa

A. Wayne Lacy, Auburn Univ., Mtgy.

Dan Whitson, Decatur

E. M. Wilson, Univ. South Alabama

The Journal is the official publication of the Alabama Academy of Science, and is indexed in Biological Abstracts, Chemical Abstracts, America: History and Life, and Historical Abstracts

Publication and Subscription Policies

Submission of Manuscripts. Submit all manuscripts and pertinent correspondence to the EDITOR. Each manuscript will receive two simultaneous reviews. For style details, follow Instruction to Authors, J. Ala. Acad. Sci. 50:96-97, 1979.

Reprints: Requests for reprints must be addressed to authors.

Subscriptions and Journal Exchanges: Address all correspondence to the CHAIRMAN OF THE EDITORIAL BOARD.

Advertising, News Releases: Advertisements and news releases will not be published in the Journal.

CONTENTS

ARTICLES

An Acardius Acephalus Human Fetus James W. Ward and James B. Hutcheson	62
Summer Flora of Horseshoe Bend National Military Park, Alabama James W. Petranka, Anita Hutto, and John D. Freeman . . .	70
Ovarian Development of Smallmouth Bass in Pickwick Reservoir Wayne A. Hubert and Vester P. Mitchell, Jr.	87
INSTRUCTIONS TO AUTHORS	96

AN ACARDIUS ACEPHALUS HUMAN FETUS¹

James W. Ward
Department of Pharmacology
University of South Alabama
College of Medicine
Mobile, AL 36688

James B. Hutcheson
Tampa General Hospital
Tampa, FL 33606

INTRODUCTION

This report describes a human fetal monster that does not possess a head or a heart. It is designated as an acardius acephalus fetus. Such abnormalities occur only in multiple births, most commonly in monozygotic twins with a monochorionic placenta, but in rare instances in triplet and quadruplet births. The incidence of such malformations has been calculated as one in about 35,000 births, occurring in less than one percent of identical twin pregnancies (Gillim and Hendricks, 1953). The sexes are always the same.

MATERIALS AND METHODS

The history and the records pertaining to this case are unfortunately negligible. The male twins were stillborn. The acardius acephalus twin was x-rayed and measured. A complete dissection under low magnification was made. Representative samples of all tissues were preserved in 10 percent formalin, embedded in paraffin, sectioned at 10 micra, and stained in hematoxylin and eosin. Additional sections of the "medulla" and spinal cord were impregnated and stained in protargol-orange G-fast green or with thionin.

RESULTS

This acardius acephalus fetus weighed 415 grams after being preserved in 10 percent formalin: whereas, the normal twin weighed 440 grams. The arcadius twin measured 130 millimeters from its most cephalic end to the rump. The upper and lower extremities, all appearing normal, were attached to relatively normal shoulders and to a pelvic girdle, respectively. There were two placentas and two umbilical cords, all appearing normal, one of each for each twin. The anus and external genitalia appeared normal. The acardius acephalus fetus exhibited many external abnormalities. Four digits were present on each hand (fig. 2). The small 5th digits were missing. The nails were normal. Four toes were present on the left foot and three on the right foot (fig. 3). The

¹Manuscript received 14 September 1978; accepted 16 January 1979.

An Acardius Acephalus Human Fetus

head and neck were absent. There was a slit-like cul-de-sac on the cephalic end of the body in the ventral area of the neck. Extending externally from it was a papillary-like structure measuring three millimeters in length. The fold of the cul-de-sac was composed of skin-like tissue covering the area of the vertebral foramen of the atlas.

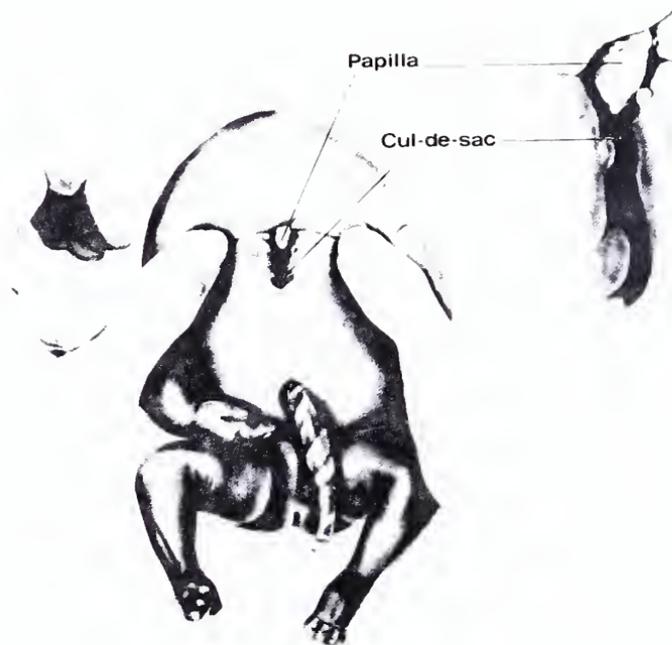


Fig. 1. External appearance of acardiac acephalic fetus. Note the complete absence of head; cul-de-sac and papilla extending from cul-de-sac.



Fig. 2. Appearance of hands. Note the absence of one finger from each hand.



Fig. 3. Appearance of feet. Note the absence of one toe on left foot and two toes on right foot.

X-ray studies revealed that most of the bones of the extremities were present except for some of the phalanges and related carpal and metacarpal bones. There were 32 vertebrae present, 11 pairs of ribs, the manubrium and the body of the sternum, clavicles, scapulae and the pelvic girdle.

Dissection of the acardius acephalus fetus showed anatomic variations. The inferior vena cava was found to be normal. The right common iliac vein received the umbilical vein. The inferior vena cava received the renals, intestinals and innominate veins. The principal groups of muscles were present and appeared to be normal.

Nerves innervating these groups of muscles were identified. Spinal branches of the accessory nerves innervated the trapezius muscles. No other cranial nerves were identified. The spinal nerves and ganglia and the sympathetic ganglia were present and grossly normal. The lateral, posterior and medial cord of the brachial plexus was identified as well as the trunks of the brachial plexus. The axillary nerve, lateral cutaneous nerves, medial, radial, and ulnar nerves were present and appeared normal. The lumbar plexus and its branches appeared to be normal.

The diaphragm was in a normal position, separating the thoracic and abdominal cavities. The large dorsal aorta extended through the abdominal and thoracic cavities. Extending cephalad from the aorta were two

An Acardius Acephalus Human Fetus

branches each of which gave rise to a subclavian artery and a carotid artery. All branches of the subclavian arteries were present except the vertebral arteries. The carotid arteries did not bifurcate into internal carotid and external carotid branches. The dorsal aorta gave off the normal intercostal and lumbar arteries, the coeliac, the superior mesenteric, the renal, the testicular, and the inferior mesenteric. It terminated by bifurcating into the common iliac arteries. The umbilical arteries arose from the right common iliac artery.

The inferior vena cava was formed normally by the union of the common iliac veins. It received the umbilical vein, renal veins, intestinal veins and jugular veins.

The thoracic cavity was entirely lacking of viscera. No cardiac muscle was observed microscopically. In the abdomen all divisions of the alimentary canal except in the cranial part were in relatively normal position. Lobulated kidneys, normal appearing adrenal glands, ureters and urinary bladder were identified. No remnant of the lungs, liver, gallbladder, bile ducts, pancreas, and spleen was located.

The external genitalia appeared normal (fig. 4). The undescended testes were evident in the lower portion of the pelvic cavity.

Upon exposing the central nervous system it was determined that the "medulla" was the only division of the brain that was present (fig. 5). It appeared as an enlargement at the cephalic end of the cervical cord. Grossly the spinal cord appeared normal. All regions were evident as well as the cervical and the lumbar enlargements. The spinal dura, arachnoid and pia were apparently normal. The arterial supply of the spinal cord was identified as normal except at the most cephalic end.

Owing to inadequate fixation of the "medulla" and the spinal cord it was not possible to make a detailed microscopic study of them; however, some structures were identifiable. The anterior horn neurons were evident in the cord, but it was not possible to determine whether most other cells were astrocytes or neuroblasts. The substantia gelatinosa and a probable nucleus dorsalis were identified in a poor state of preservation. Nerve fibers crossing in the anterior white commissure were demonstrated. Few fibers were identified in the dorsolateral funiculus. Numerous silver impregnated fibers were observed in the dorsal and the lateral funiculi. Intermediate cells were observed migrating toward the surface of the cord. Clusters of cells were present in the neural canal. Ganglion-like cells were identified in the lateral part of the anterior funiculus and outside the cord near the ventral root. Similar cells were identified by Humphrey (1944, 1947). There was a cul-de-sac from the ependema of the cord. Cells in the ependema appeared normal and some are presumed to be neuroblasts.

The "medulla" was in such a poor state of preservation that few definite structures could be identified. There were numerous nerve fibers, some in bundles and some individual fibers coursing in all directions, but an organized pattern was not evident. Neurons were also numerous throughout the sections, but no identifiable nuclei could be recognized.

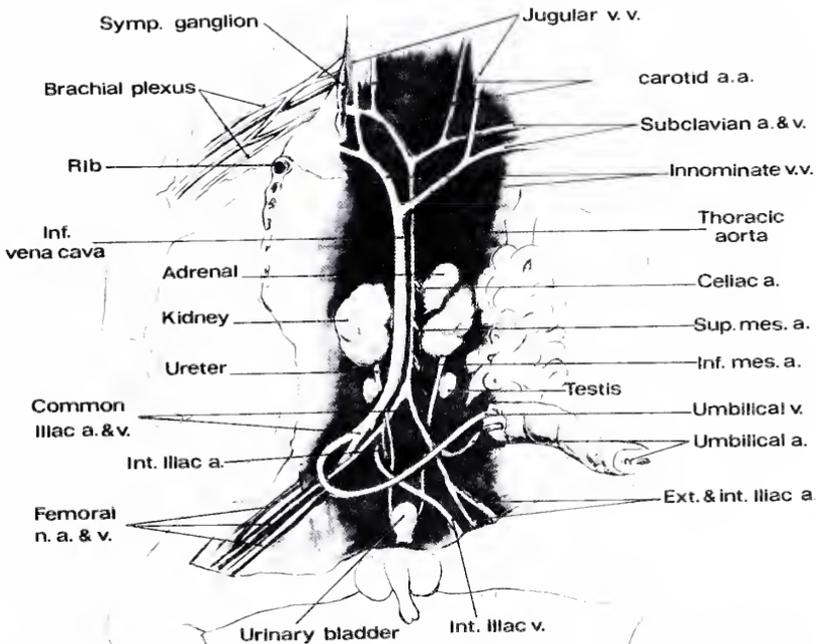


Fig. 4. Contents of thoracic and abdominal cavities. Note the complete absence of heart, lungs and liver (diaphragm present but not shown); presence of inferior vena cava and tributaries; innominate veins and arteries; one umbilical artery; brachial plexus and sympathetic ganglia.

DISCUSSION

The purpose of this report is to record another example of a type of human monster to the present recordings of about 200 similar cases presently found in the literature (fig. 1).

The specimen described in this report is designated as an acardius acephalic fetus, since the head and heart are completely absent. Saint Helaire in 1836 was the first investigator to describe this deformity (Bose et al., 1964).

An Acardius Acephalus Human Fetus

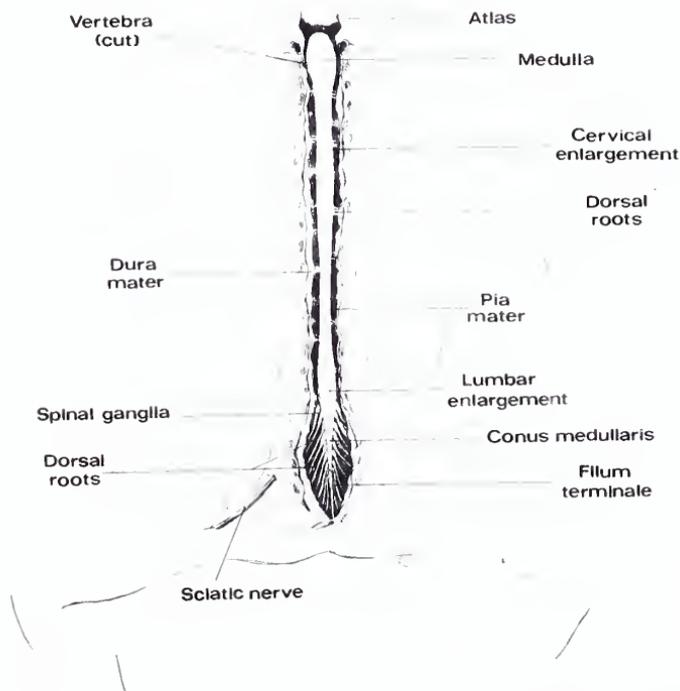


Fig. 5. Appearance of nervous system. Note the absence of brain except "medulla"; presence of medulla, cord, dorsal spinal nerve roots, and meninges.

The classification of such fetuses varies somewhat with the classification of the different authors depending primarily upon the extent of fetal development and upon the structures that are missing. An acardius acephalus fetus is one in which the heart and head are absent. If only a part of the cranium is absent the fetus is designated as a paracephalus. If only the caudal end of the body and legs are present, it is designated as acardius amyelacephalus. The term acardius amorphus is applied when the fetus is a formless mass (Hommes, 1957). Such abnormalities as described above occur only in multiple births, usually in monozygote twins but in rare instances in triplet and quadruplet births. The sexes are always the same. Simonds and Gowen (1925) called attention to the fact that acardius fetuses occur in other vertebrates. In reviewing the literature they reported 12 in cattle, three in sheep and one in a bird.

BIBLIOGRAPHY

Ariens Kappers, C. U., G. C. Huber and E. C. Crosby. 1936. The comparative anatomy of the nervous system of vertebrates, including man. The Macmillan Company, New York.

- Bear, J. 1931. Iniencephalus, with the report of a case. *Am. J. Obst. Gyn.* 22:429-432.
- Bodian, D. 1936. A new method for staining nerve fibers and nerve endings in mounted paraffin sections. *Anat. Rec.* 65:89-97.
- _____. 1937. The staining of paraffin sections of nervous tissues with activated protargol. The role of fixatives. *Anat. Rec.* 69:153-162.
- Bose, S., J. S. Makhami and S. V. Thaker. 1964. Iniencephaly. A report of 2 cases. *Ind. J. Med. Sci.* 18:590-594.
- Brodsky, I. 1939. Four examples of iniencephalus, with a statistical review of literature. *Med. J. Aust.* 2:795-800.
- Burkl, W. 1953. Das nervöse Zentralorgan eines Acardius acephalus. *Acat Anat.* 17:84.
- Buxbaum, H. and D. V. Wachsmann. 1938. Case of acephalus holoacardius. *Am. J. Obst. Gyn.* 36:1055.
- Campbell, M. and H. D. Shepard. 1905. The circulatory and anatomical abnormalities of an acardiac fetus of rare form. *Lancet.* 2:941-944.
- Cavanaugh, M. W. 1951. Quantitative effects of the peripheral innervation area on nerves and spinal ganglion cells. *J. Comp. Neur.* 94:181-220.
- Crelin, E. S. 1969. *Anatomy of the Newborn.* Lea & Febiger, Philadelphia, Pa.
- Das, K. 1902. Acardiacus anceps. *J. Obst. Gyn. Br. Emp.* 2:341-355.
- Elliott, H. C. 1943. Studies on the motor cells of the spinal cord. *Am. J. Anat.* 72:29-38.
- Gillim, D. L. and C. H. Hendricks. 1953. Holoacardius. Review of the literature and case report. *Obst. & Gyn.* 2:647-653.
- Hamilton, W. J., J. D. Boyd and H. W. Mossman. 1952. *Human Embryology.* Heffner and Sons, Ltd.
- Hayes, W. I. 1921-22. A human foetus exhibiting iniencephaly and other abnormalities. *J. Anat.* 56:155-159.
- _____. 1972. A human foetus exhibiting iniencephaly and other abnormalities. *Teratology* 6:36.
- Hommel, O. R. 1957. Primary entodermal defects. Thesis. J. van Campen, Amsterdam.
- Howkins, J. and R. S. Lawrie. 1939. Iniencephalus. *J. Obst. Gyn. Br. Comm.* 46:25-31.

An Acardius Acephalus Human Fetus

- Humphrey, T. 1944. Primitive neurons in the embryonic human central nervous system. *J. Comp. Neur.* 81:1-45.
- _____. 1947. Sensory ganglion cells within the central canal of the embryonic human spinal cord. *J. Comp. Neur.* 86:1-35.
- _____. 1950. Intramedullary sensory ganglion cells in the roof plate area of the embryonic human spinal cord. *J. Comp. Neur.* 92: 333-400.
- Langman, J. 1969. *Medical Embryology*. Williams & Wilkins Co., Baltimore, Md.
- Lemire, R. J., J. B. Beckwith and T. H. Shepard. 1971. Iniencephaly and anencephaly with spinal retroflexion. A comparative study of eight human specimens. *Teratology* 6:27-36.
- Rielander. 1909. Demonstration eines Acardius acormus. *Verh. Deutsche Ges. f. Gynäk.* Strassbourg 13:497.
- Saint Hilaire, I. G. 1836. *Histoire Des Anomalies*. ii, 310.
- Scott, J. M. and M. A. Ferguson-Smith. 1973. Heterokaryotypic monozygotic twins and the acardiac monster. *J. Obst. Gyn. Br. Comm.* 80: 52-59.
- Simonds, J. P. and G. A. Gowen. 1925. Fetus amorphus: Report of a case. *Surg., Gyn. & Obst.* 41:171.
- Smithells, R. W., E. E. D'Arcy and E. F. McAllister. 1968. The outcome of pregnancies before and after the birth of infants with nervous system malformations. *Dev. Med. Child. Neur.* 10:Suppl. 15:6-10.
- Stockhard, C. 1921. Developmental and structural expression, etc. *Am. J. Anat.* 28, No. 2.
- Wilson, E. A. 1972. Holocardius. *Obst. & Gyn.* 40:740-748.
- Yoshihara, H. and H. Maisel. 1973. An acardiac human fetus. *Anat. Rec.* 117:209-218.

SUMMER FLORA OF HORSESHOE BEND
NATIONAL MILITARY PARK, ALABAMA¹

James W. Petranka², Anita Hutto, and John D. Freeman
Department of Botany and Microbiology
Auburn University Agricultural Experiment Station
Auburn, AL 36830

Abstract. The vascular flora of Horseshoe Bend National Military Park, located in Tallapoosa County in the Piedmont of east-central Alabama, was studied during the summer of 1974. More than 400 species representing 108 families were observed or collected during the study period or have been subsequently documented for the park area. The names of these taxa are presented as a checklist.

INTRODUCTION

Few floristic studies (Earle, 1902; McVaugh, 1943) and no recent checklists have been published for areas of the Piedmont of Alabama. Manuals and floras in general use in the Southeast (e.g., Fernald, 1950; Radford *et al.*, 1968; Small, 1933) were either based upon studies in other, distant areas or have limited utility because of nomenclature that is out-dated and virtually obsolete. Results of this study of a small non-mountainous area of only 3.187 square miles may serve as an indication of species that one might expect to find in similar areas elsewhere in east-central Alabama, but no claim of applicability is made for our checklist outside the summer season and the area studied. We attempted to document the occurrence of all vascular plant species present in summer in Horseshoe Bend National Military Park (H.B.N.M.P.) by collecting herbarium specimens of each species with sexual reproductive stages and by listing as sight records all others identifiable from vegetative parts alone. Although early spring and late fall flowering plants were usually excluded from collection during the study period, subsequent field work and herbarium study have furnished additional records for several late spring and early fall plants.

STUDY AREA AND HABITAT TYPES

The park is located near the southern extremity of the Piedmont Province (Fenneman, 1938), an extensive formation of metamorphic and igneous rocks of Paleozoic to Precambrian age, which parallels the Atlantic Coastal Plain from Pennsylvania to Alabama. The Piedmont

¹Manuscript received 8 November 1978; accepted 2 April 1979.

²Present address: Department of Biological Sciences, University of Kentucky, Lexington, KY 40506.

Summer Flora of Horseshoe Bend

occupies a triangular area of approximately 5,000 square miles within Lee, Chambers, Randolph, Cleburne, Clay, Coosa, Chilton, Elmore, and Tallapoosa counties, Alabama. Granite, gneiss, and schist bedrocks characterize the Piedmont and generally weather to produce well drained, reddish loamy or clayey soils (Harper, 1943). To the south, the Piedmont abuts abruptly with the sandy soils of the Coastal Plain, whereas it merges gradually with the more mountainous Blue Ridge Province in Calhoun, Talladega, and Shelby counties to the north.

Horseshoe Bend National Military Park was established in 1959 in north-central Tallapoosa County to mark the site of the Battle of Horseshoe Bend which ended the supremacy of the Creek Nation in the Southeastern United States. The park includes a wide loop of the Tallapoosa River and approximately 2,000 acres of its watershed. Prior to acquisition by the Park Service, most of this acreage was used for row crops or livestock and timber production. It has since remained relatively undisturbed except for small areas near the visitors' center and roadsides, which are mowed regularly. Maintenance of nature trails and service roads has caused minor disturbances in other areas. The variety of land use and management practiced prior to 1959 has resulted in a diverse assemblage of successional communities, each with its own characteristic components, which cause the flora to be fairly diverse. A map indicating the location of plant community types in H.B.N.M.P. is presented as Figure 1. Habitats with the greatest variety of species restricted to them include bottomland hardwood forests, beaver swamp, rock outcrops, and river shoals. Most species in the checklist can be related to Figure 1 by use of the numerical system presented below:

- 0--Weedy places, dry roadsides, and other disturbed areas.
- 1--Regularly mowed fields.
- 2--Aster--Goldenrod--Broomsedge.
- 3--Shrubs--small pines.
- 4--Pine dominance: little hardwood understory.
- 5--Pine dominance: moderate to dense hardwood understory.
- 6--Bottomland hardwoods.
- 7--Transition hardwoods of slopes.
- 8--Upland hardwoods.
- 9--Beaver swamp and other open marshes, wet ditches.

RANGE EXTENSIONS FOR UNCOMMON SPECIES

No endangered or threatened species were found within the park, but new localities and/or geographic range extensions for certain species uncommon in the Piedmont were discovered:

- Medeola virginiana* (Indian cucumber root).
- Amanthium muscaetoxicum* (fly-poison).
- Habenaria cristata* (crested fringed-orchid), northernmost Alabama locality.
- Habenaria flava* (southern rein orchid).
- Malaxis unifolia* (green adder's mouth).
- Cimicifuga racemosa* (black cohosh), southernmost Alabama locality.
- Galax aphylla* (galax), southernmost Alabama locality.

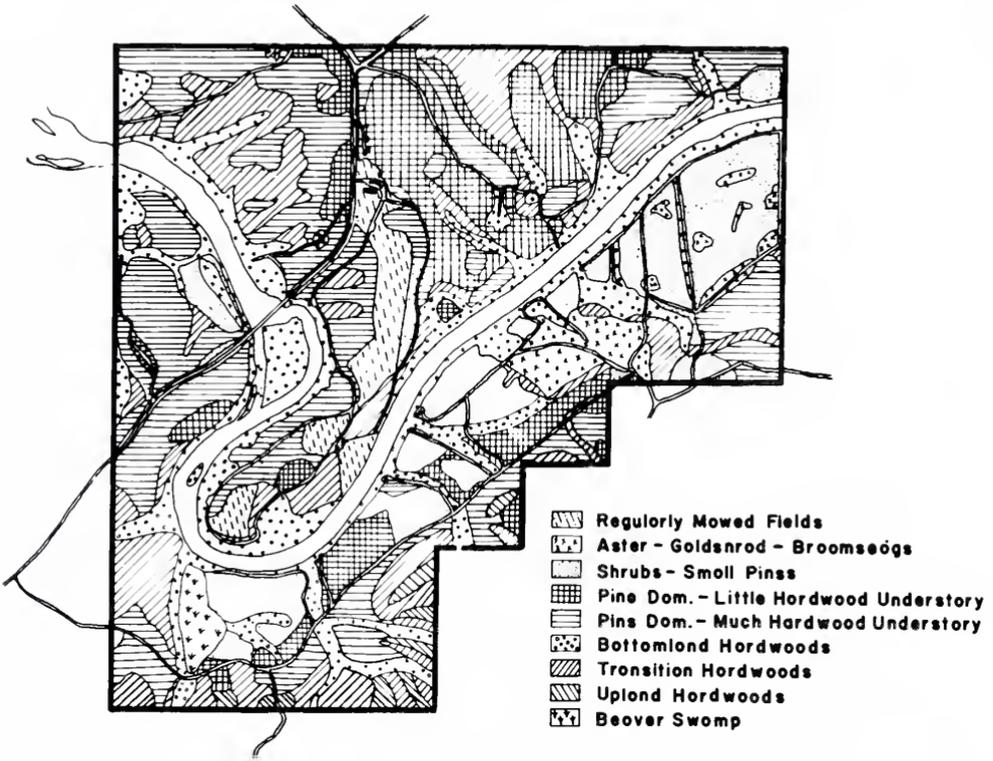


Figure 1. Vegetation map of Horseshoe Bend National Military Park.

LIST OF VASCULAR PLANT SPECIES

The order of taxonomic treatment of families in the following list is that of Radford *et al.* (1968), whose nomenclature is also generally adopted. Within families, the genera, species, subspecies, and varieties, respectively, are treated in alphabetical order. When unavailable from the literature used for identification, common names of important weeds and woody plants are adapted from those assigned by the Weed Science Society of America (1971).

Lycopodiaceae

Lycopodium flabelliforme (Fernald) Blanchard. Running pine (5).

Selaginellaceae

Selaginella apoda (L.) Spring. Meadow spikemoss (6).

Summer Flora of Horseshoe Bend

Ophioglossaceae

- Botrychium biternatum* (Sav.) Underwood. Southern grapefern (6).
B. virginianum (L.) Swartz. Rattlesnake fern (7).

Osmundaceae

- Osmunda cinnamomea* L. Cinnamon fern (6).
O. regalis L. Royal fern (6).

Pteridaceae

- Cheilanthes lanosa* (Michaux) D. C. Eaton. Hairy lip-fern (7).
Pteridium aquilinum (L.) Kuhn. Bracken fern (4,5,8).

Aspidiaceae

- Athyrium asplenoides* (Michaux) A. A. Eaton. Southern lady-fern (6).
Onoclea sensibilis L. Sensitive fern (6).
Polystichum acrostichoides (Michaux) Schott. Christmas fern (6,7).
Thelypteris noveboracensis (L.) Nieuwland. New York fern (6).

Blechnaceae

- Woodwardia areolata* (L.) Moore. Netted chain-fern (6).

Aspleniaceae

- Asplenium platyneuron* (L.) Oakes. Ebony spleenwort (2,4,7).

Polypodiaceae

- Polypodium polypodioides* (L.) Watt. Resurrection fern (6,7).

Pinaceae

- Pinus echinata* Miller. Shortleaf pine (3-8).
P. palustris Miller. Longleaf pine (3-8).
P. taeda L. Loblolly pine (3-8).

Cupressaceae

- Juniperus virginiana* L. Eastern redcedar (2,7).

Typhaceae

- Typha latifolia* L. Common cat-tail (9).

Sparganiaceae

- Sparganium americanum* Nuttall. Bur-reed (9).

Alismataceae

- Sagittaria latifolia* Willd. Duck-potato (9).

Poaceae (Gramineae)

- Andropogon virginicus* L. Broomsedge (2).
Aristida dichotoma Michaux. Churchmouse threeawn (0,2).
A. oligantha Michaux. Prairie threeawn (2).
Arundinaria gigantea (Walter) Muhl. Switchcane (6,9).
Cynodon dactylon (L.) Persoon. Bermuda grass (0,1).
Digitaria filiformis (L.) Koeler. Slender crabgrass (0,1,2).
D. sanguinalis (L.) Scopoli. Large crabgrass (0,1).
Eleusine indica (L.) Gaertner. Goose grass (0).
Elymus virginicus L. Virginia wild rye (6,9).
Eragrostis capillaris (L.) Nees. Love grass (0).
Erianthus contortus Baldwin ex Ell. Plume grass (3).
Melica mutica Walter. Melic grass (7).
Panicum commutatum Schultes. Panic grass (6).
P. dichotomiflorum Michaux. Fall panicum (0,2).
P. polyanthes Schultes. Panic grass (9).
Paspalum dilatatum Poir. Dallis grass (0,1).
P. notatum Flugge var. *saurae* Parodi. Bahia grass (0,1).
Sorghum halepense (L.) Persoon. Johnson grass (0,1).
Sporobolus poiretii (R.&S.) Hitchcock. Smut grass (0).
Stipa avenacea L. Needle grass (8).
Tridens flavus (L.) Hitchcock. Purple-top (0,2).
Uniola latifolia Michaux. Broadleaf uniola (6).
U. sessiliflora Poir. Sessile flower uniola (6,7).

Cyperaceae

- Carex leptalea* Wahlenberg. No common name (9).
Cyperus ovularis (Michaux) Torrey. No common name (0).
C. strigosus L. False nutsedge (0).
Eleocharis obtusa (Willd.) Schultes. Blunt spikerush (9).
Scirpus cyperinus (L.) Kunth. Woolly bulrush, wool-grass bulrush (9).
S. purshianus Fernald. Pursh bulrush (9).

Araceae

- Arisaema dracontium* (L.) Schott. Green dragon (6).
A. triphyllum (L.) Schott. Jack-in-the-pulpit (6,7).
Peltandra virginica (L.) Kunth. Arrow arum (6,9).

Bromeliaceae

- Tillandsia usneoides* L. Spanish moss (7).

Commelinaceae

- Commelina virginica* L. Virginia dayflower (6).
Tradescantia ohioensis Raf. Ohio spiderwort (8).
T. virginiana L. Virginia spiderwort (8).

Pontederiaceae

- Pontederia cordata* L. Pickerelweed (0,9).

Summer Flora of Horseshoe Bend

Juncaceae

- Juncus effusus* L. Soft rush (9).
J. validus Coville. No common name (9).
Luzula multiflora (Retzius) Lej. Woodrush (7).

Liliaceae

- Allium bivalve* (L.) Kuntze. False garlic (0).
A. canadense L. Wild onion (0).
Amianthium muscaetoxicum (Walter) Gray. Fly-poison (7).
Lilium michauxii Poiret. Carolina lily (7).
Medeola virginiana L. Indian cucumber root (7).
Polygonatum biflorum (Walter) Ell. Solomon's-seal (7).
Smilacina racemosa (L.) Desf. False Solomon's-seal (7).
Smilax bona-nox L. Saw greenbrier (3,4).
S. glauca Walter. Cat greenbrier (2-8).
S. rotundifolia L. Common greenbrier (0).
Stenanthium gramineum (Ker) Morong. Featherbells (7,8).
Trillium catesbaei Ell. Catesby's trillium (5,7).
T. underwoodii Small. Underwood's trillium (7).
Uvularia perfoliata L. Perfoliate bellwort (6,7).
U. sessilifolia L. Sessile-leaf bellwort (6,7).
Yucca filamentosa L. Bear-grass (4,8).

Dioscoreaceae

- Dioscorea batatas* Dcne. Cinnamon vine (6).
D. villosa L. Wild yam (5,7,8).

Amaryllidaceae

- Agave virginica* L. False aloe (8).
Hymenocallis occidentalis (LeConte) Kunth. Spider lily (6).
Hypoxis hirsuta (L.) Coville. Yellow stargrass (5-7).
Zephyranthes atamasco (L.) Herbert. Atamasco lily (9).

Iridaceae

- Iris cristata* Aiton. Dwarf crested iris (7).
Sisyrinchium mucronatum Michaux. Blue-eyed grass (0).

Orchidaceae

- Goodyera pubescens* (Willd.) R. Brown. Downy rattlesnake plantain (5,7).
Habenaria clavellata (Michaux) Sprengel. Small green wood-orchid (6).
H. cristata (Michaux) R. Brown. Crested fringed-orchid (5,6).
H. flava (L.) R. Brown. Southern rein-orchid (6).
Malaxis unifolia Michaux. Green adder's mouth (5).
Spiranthes cernua (L.) Richard. Nodding ladies' tresses (9).
Tipularia discolor (Pursh) Nuttall. Cranefly orchid (6-8).

Saururaceae

- Saururus cernuus* L. Lizard's tail (6).

Salicaceae

- Populus deltoides* Marshall. Cottonwood (6).
Salix nigra Marshall. Black willow (6).

Juglandaceae

- Carya cordiformis* (Wang.) K. Koch. Bitternut hickory (6).
C. glabra Miller. Pignut hickory (7,8).
C. illinoensis (Wang) K. Koch. Pecan (6).
C. tomentosa (Poiret) Nuttall. Mockernut hickory (7,8).
Juglans cinerea L. Butternut, white walnut (6).
J. nigra L. Black walnut (6,7).

Betulaceae

- Alnus serrulata* (Aiton) Willd. Hazel alder (6).
Betula nigra L. River birch (6).
Carpinus caroliniana Walter. American hornbeam (6).
Ostrya virginiana (Miller) K. Koch. Eastern hophornbeam (6,7).

Fagaceae

- Castanea pumila* (L.) Miller. Allegheny chinquapin (7).
Fagus grandifolia Ehrhart. American beech (6,7).
Quercus alba L. White oak (6-8).
Q. falcata Michaux. Southern red oak (8).
Q. marilandica Muenchh. Blackjack oak (7,8).
Q. michauxii Nuttall. Swamp chestnut oak (6).
Q. nigra L. Water oak (6,7).
Q. phellos L. Willow oak (6,7).
Q. rubra L. Red oak (8).
Q. stellata Wang. Post oak (8).
Q. velutina Lam. Black oak (7,8).

Ulmaceae

- Celtis occidentalis* L. Western hackberry (3,8).
Ulmus alata Michaux. Winged elm (3).
U. rubra Muhl. Slippery elm (6,7).

Moraceae

- Morus rubra* L. Red mulberry (6).

Urticaceae

- Boehmeria cylindrica* (L.) Swartz. False nettle (6).
Laportea canadensis (L.) Weddell. Wood-nettle (6).

Loranthaceae

- Phoradendron serotinum* (Raf.) M. C. Johnston. Mistletoe (6-8).

Summer Flora of Horseshoe Bend

Aristolochiaceae

- Aristolochia tomentosa* Sims. Pipevine (6).
Hexastylis arifolia (Michaux) Small. Arrowleaf wild ginger (5,7,8).

Polygonaceae

- Polygonum cespitosum* Blume var. *longisetum* (DeBruyn) Stewart. Long-bristle smartweed (6).
P. coccineum Muhl. ex Willd. Swamp smartweed (0).
P. punctatum Ell. Dotted smartweed (0).
Rumex crispus L. Curlydock (0).
Tovara virginiana (L.) Raf. Jumpseed (6).

Amaranthaceae

- Amaranthus hybridus* L. Pigweed (0).

Phytolaccaceae

- Phytolacca americana* L. Common pokeweed (0).

Caryophyllaceae

- Cerastium glomeratum* Thuillier. Mouse-ear chickweed (1).
Silene stellata (L.) Aiton f. Starry campion (7).
S. virginica L. Fire pink (7).
Stellaria media (L.) Cyrillo. Chickweed (0,1).

Cabombaceae

- Brasenia schreberi* Gmelin. Water-shield (9).

Ranunculaceae

- Anemone quinquefolia* L. Wood anemone (7).
Cimicifuga racemosa Nuttall. Black cohosh (7).
Clematis glaucophylla Small. Leather-flower (6).
C. virginiana L. Virgin's bower (6).
Hepatica acutiloba DC. Sharp-lobe liverleaf (7).
H. americana (DC.) Ker. Round-lobe liverleaf (7).
Ranunculus recurvatus Poir. Buttercup (6,7).
Thalictrum revolutum DC. Tall meadow rue (6).
T. thalictroides (L.) Boivin. Rue anemone, windflower (7).
Xanthorhiza simplicissima Marshall. Yellow-root (6).

Berberidaceae

- Podophyllum peltatum* L. May-apple (6,7).

Menispermaceae

- Calycocarpum lyonii* (Pursh) Nuttall. Cupseed (6).
Cocculus carolinus (L.) DC. Coralbeads (3,4).

Magnoliaceae

- Liriodendron tulipifera* L. Tulip tree (5-7).
Magnolia acuminata L. Cucumber tree (7).
M. virginiana L. Sweetbay magnolia (6).

Annonaceae

- Asimina parviflora* (Michaux) Dunal. Dwarf pawpaw (7).

Lauraceae

- Sassafras albidum* (Nuttall) Nees. Sassafras (0,3).

Brassicaceae

- Lepidium virginicum* L. Virginia pepperweed (0).

Podostemaceae

- Podostemum ceratophyllum* Michaux. Riverweed (river shoals).

Crassulaceae

- Penthorum sedoides* L. Ditch stonecrop (6,9).

Saxifragaceae

- Decumaria barbara* L. Climbing hydrangea (6,7).
Hydrangea arborescens L. Wild hydrangea (7).
H. quercifolia Bartr. Oakleaf hydrangea (7).
Philadelphus inodorus L. Mock-orange (6).
Tiarella cordifolia L. Foamflower (6,7).

Hamamelidaceae

- Hamamelis virginiana* L. Witch-hazel (6).
Liquidambar styraciflua L. Sweet-gum (6,7).

Platanaceae

- Platanus occidentalis* L. American sycamore (6).

Rosaceae

- Agrimonia parviflora* Aiton. Harvest-lice (6,7).
A. pubescens Wallroth. Hairy agrimony (6).
Crataegus spathulata Michaux. Hawthorn (3,5,8).
C. uniflora Muenchh. Dwarf hawthorn (3,5).
Duchesnea indica (Andrz.) Focke. Indian strawberry (0).
Fragaria virginiana Duchesne. Strawberry (0,2).
Geum canadense Jacquin. Avens (0,6).
Gillenia stipulata (Muhl.) Baillon. Indian-physic (7).
Malus angustifolia (Aiton) Michaux. Wild crabapple (7).

Summer Flora of Horseshoe Bend

- Prunus angustifolia* Marshall. Chickasaw plum (0,3).
P. serotina Ehrhart. Black cherry (3-5).
P. umbellata Ell. Hog plum (4,5).

Fabaceae (Leguminosae)

- Albizia julibrissin* Durazzini. Silktree albizia (0).
Amorpha fruticosa L. False indigo (6).
Amphicarpa bracteata (L.) Fernald. Hog peanut (6).
Apios americana Medicus. Groundnut, American potatobean (0,6).
Cassia fasciculata Michaux. Partridge-pea (0,2).
C. nictitans L. Sensitive partridge-pea (0).
Centrosema virginianum (L.) Benth. Virginia butterfly-pea (0,1).
Cercis canadensis L. Eastern redbud (7).
Coronilla varia L. Crown vetch (0).
Desmodium marilandicum (L.) DC. Beggar-ticks (4,5).
D. nudiflorum (L.) DC. Nudeflower beggar-ticks (7,8).
D. tortuosum (Swartz) DC. Florida beggar-ticks (0).
D. viridiflorum (L.) DC. Beggar-ticks (4,5).
Gleditsia triacanthos L. Honey locust (0,3,7).
Lespedeza cuneata (Dumont) G. Don. Sericea lespedeza (0).
L. repens (L.) Barton. Creeping lespedeza (2-4).
Pueraria psoralioides (Walter) Cory. Samson snakeroot (2-4).
Pueraria lobata (Willd.) Ohwi. Kudzu (0).
Schrankia microphylla (Solander ex Smith) Macbride. Little-leaf sensitive-brier (2,4).
Stylosanthes biflora (L.) BSP. Pencil-flower (0).
Tephrosia virginiana (L.) Persoon. Goat's rue (4).
Trifolium repens L. White clover (0,1).
Vicia sp. Vetch (7).

Oxalidaceae

- Oxalis dillenii* Jacquin. Southern yellow wood-sorrel (0).
O. stricta L. Common yellow wood-sorrel (6,7).

Geraniaceae

- Geranium maculatum* L. Wild geranium (6,7).

Meliaceae

- Melia azedarach* L. China-berry (0,3).

Polygalaceae

- Polygala curtissii* Gray. Curtiss' milkwort (0).
P. grandiflora Walter. Large-flower polygala (0).

Euphorbiaceae

- Cnidioscolus stimulosus* (Michaux) Engelm. & Gray. Tread-softly, bull-nettle (0,1,4).
Euphorbia corollata L. Flowering spurge (4,8).

Anacardiaceae

- Rhus copallina* L. Winged sumac (3).
R. glabra L. Common sumac (3).
R. radicans L. Poison ivy (5,7,8).
R. toxicodendron L. Poison oak (4).
R. typhina L. Staghorn sumac (3).

Aquifoliaceae

- Ilex decidua* Walter. Possum haw (6-8).
I. opaca Aiton. American holly (6).
I. vomitoria Aiton. Yaupon (0).

Celastraceae

- Euonymus americanus* L. Strawberry bush (6,7).

Staphyleaceae

- Staphylea trifolia* L. Bladdernut (6).

Aceraceae

- Acer negundo* L. Boxelder (6,7).
A. rubrum L. Red maple (6).
A. saccharum Marshall ssp. *floridanum* (Chapman) Desmarais. Florida maple (6,7).

Hippocastanaceae

- Aesculus pavia* L. Red buckeye (6,7).

Balsaminaceae

- Impatiens capensis* Meerb. Spotted jewelweed (6).

Rhamnaceae

- Ceanothus americana* L. New Jersey tea (4).

Vitaceae

- Parthenocissus quinquefolia* (L.) Planchon. Virginia creeper (4,5,7,8).
Vitis baileyana Munson. Possum grape (6).
V. rotundifolia Michaux. Muscadine (5,7).

Tiliaceae

- Tilia heterophylla* Vent. White basswood (7).

Malvaceae

- Hibiscus moscheutos* L. Rose-mallow (6).

Summer Flora of Horseshoe Bend

Hypericaceae

- Hypericum drummondii* (Grev. & Hooker) T. & G. Drummond's St. John's wort (0).
H. frondosum Michaux. St. John's wort (7).
H. gentianoides (L.) BSP. Pinweed (0).
H. hypericoides (L.) Crantz. St. Andrew's cross (0).
H. mutilum L. No common name (6).
H. punctatum Lam. Spotted St. John's wort (0,6).

Cistaceae

- Lechea racemulosa* Michaux. Pinweed (0).

Violaceae

- Viola eriocarpa* Schweinitz. Yellow violet (7).
V. floridana Brainerd. Blue violet (6).
V. palmata L. Palmate violet (6,7).
V. pedata L. Bird-foot violet (4,5,8).
V. sororia Willd. Downy blue violet (6,7).

Passifloraceae

- Passiflora incarnata* L. Maypops (0).

Cactaceae

- Opuntia compressa* (Salisbury) Macbride. Spreading prickly pear (2).

Melastomataceae

- Rhexia mariana* L. Meadow-beauty (0).
R. virginica L. Virginia meadow-beauty (0).

Onagraceae

- Ludwigia palustris* (L.) Ell. Marsh purslane (6).
Oenothera biennis L. Perennial sundrops (0).
O. speciosa Nuttall. White evening primrose (0).

Araliaceae

- Aralia spinosa* L. Devil's-walking-stick (7,8).

Apiaceae (Umbelliferae)

- Apium leptophyllum* (Persoon) F. Mueller. Marsh parsley (0).
Cicuta maculata L. Spotted water-hemlock (6).
Cryptotaenia canadensis (L.) DC. Honewort (6).
Daucus carota L. Queen Anne's lace, wild carrot (0).
D. pusillus Michaux. Dwarf wild carrot (0,1).
Eryngium prostratum Nuttall. Creeping eryngium (0).
E. yuccifolium Michaux. Rattlesnake master, button snakeroot (4).

Hydrocotyle verticillata Thunberg. Whorled pennywort (6).
Sanicula canadensis L. Black snakeroot (7).
S. smallii Bicknell. Small's snakeroot (7).
Thaspium pinnatifidum (Buckley) Gray. Tall meadow parsnip (7).
T. trifoliatum (L.) Gray. Meadow parsnip (6).

Nyssaceae

Nyssa sylvatica Marshall. Black gum (6-8).

Cornaceae

Cornus amomum Miller. Silky dogwood (6).
C. florida L. Flowering dogwood (4-8).
C. stricta Lam. Swamp dogwood (6).

Ericaceae

Chimaphila maculata (L.) Pursh. Spotted wintergreen (5).
Gaylussacia dumosa (Andrz.) T. & G. Dwarf huckleberry (8).
Kalmia latifolia L. Mountain laurel (7).
Oxydendrum arboreum (L.) DC. Sourwood (7,8).
Rhododendron canescens (Michaux) Sweet. Piedmont azalea (5,7).
Vaccinium arboreum Marshall. Sparkleberry, tree huckleberry (3-5).
V. elliotii Chapman. Highbush blueberry (3-5).

Diapensiaceae

Galax aphylla L. Galax (7).

Primulaceae

Lysimachia ciliata L. Fringed loosestrife (6).

Ebenaceae

Diospyros virginiana L. Persimmon (3,7).

Styracaceae

Halesia carolina L. Carolina silverbell (6,7).
H. diptera Ellis. Two-wing silverbell (6).
Styrax americana Lam. Storax (6).

Oleaceae

Chionanthus virginicus L. Fringe tree (8).
Fraxinus pennsylvanica Marshall. Green ash (6).
Ligustrum sinense Lour. Chinese privet (6).

Loganiaceae

Gelsemium sempervirens (L.) Aiton f. Yellow jessamine (3-5).
Polypremum procumbens L. Polypremen (0-2).
Spigelia marilandica L. Indian pink (6,7).

Summer Flora of Horseshoe Bend

Gentianaceae

Sabatia angularis (L.) Pursh. Rose-pink (0,2).

Asclepiadaceae

Asclepias quadrifolia Jacquin. Four-leaf milkweed (2,7).

A. tuberosa L. Butterfly milkweed, butterfly-weed (0,2).

Matelea suberosa (L.) Shinnars. Angle-pod (6,7).

Convolvulaceae

Cuscuta compacta Jussieu. Compact dodder (0).

Ipomoea hederacea (L.) Jacquin. Ivy-leaf morning glory (0).

I. pandurata (L.) G. F. W. Meyer. Manroot, big-root morning glory (0).

Polemoniaceae

Phlox amoena Sims. Charming phlox (7).

P. carolina L. Carolina phlox (6).

P. pilosa L. Hairy phlox (7).

Boraginaceae

Heliotropium indicum L. Turnsole, Indian heliotrope (0).

Verbenaceae

Callicarpa americana L. American beauty-berry (6,7).

Verbena bonariensis L. Tall vervain (0).

Verbena brasiliensis Vellozo. Brazilian verbena (0).

Lamiaceae (Labiatae)

Collinsonia serotina Walter. Autumnhorse-balm (7).

Dracocephalum virginianum L. Obedient plant, American dragonhead (0).

Glechoma hederacea L. Ground ivy (0).

Lamium amplexicaule L. Henbit (0).

Lycopus virginicus L. Virginia bugleweed (6).

Monarda fistulosa L. Wild bergamot (7).

M. punctata L. Spotted bee-balm (0).

Prunella vulgaris L. Heal-all (0).

Pycnanthemum incanum (L.) Michaux. Mountain mint (2).

Salvia lyrata L. Lyre-leaf sage (0,1).

Scutellaria integrifolia L. Narrow-leaf skullcap (0).

S. lateriflora L. Skullcap (6).

Teucrium canadense L. Wood-sage (2).

Solanaceae

Physalis angulata L. Angle-stem ground-cherry (0).

Solanum carolinense L. Horse-nettle (0).

Scrophulariaceae

- Aureolaria flava* (L.) Farwell. Yellow false foxglove (7).
A. virginica (L.) Pennell. Downy false foxglove (7).
Linaria canadensis (L.) Dumont. Old-field toadflax (0).
Mimulus alatus Aiton. Winged monkey-flower (0).
M. ringens L. Monkey-flower (0).
Pedicularis canadensis L. Lousewort (7).
Penstemon laevigatus Solander ex Aiton. Beard-tongue (7).
Scrophularia marilandica L. Maryland figwort (7).
Verbascum thapsus L. Woolly mullein, common mullein (0).
Veronica arvensis L. Corn speedwell (0).

Bignoniaceae

- Anisostichus capreolata* (L.) Bureau. Cross-vine (5,7).
Campsis radicans (L.) Seemann. Trumpet creeper (4,5).
Catalpa speciosa Warder ex Engelm. Catalpa (3).

Orobanchaceae

- Epifagus virginiana* (L.) Barton. Beech-drops (6,7).

Acanthaceae

- Justicia americana* (L.) Vahl. Water-willow (river shoals).
Ruellia caroliniensis (Walter) Steudel. Carolina ruellia (5,7).

Plantaginaceae

- Plantago aristata* Michaux. Bracted plantain (0).
P. lanceolata L. English plantain (0,1).
P. rugelii Dcne. Black-seed plantain (0,1).
P. virginica L. Pale-seed plantain (0).

Rubiaceae

- Cephalanthus occidentalis* L. Common buttonbush (9).
Diodia teres Walter. Poor joe (0).
D. virginiana L. Virginia buttonweed (0,1).
Galium aparine L. Catchweed bedstraw (0).
Galium spp. Stickweeds, bedstraws (7).
Houstonia caerulea L. Bluet (4,5).
H. purpurea L. Summer bluet (6,7).
H. tenuifolia Nuttall. Narrow-leaf bluet (7).
Mitchella repens L. Partridge berry (5-7).

Caprifoliaceae

- Lonicera japonica* Thunberg. Japanese honeysuckle (5).
L. sempervirens L. Coral honeysuckle (7).
Sambucus canadensis L. Elderberry, American elder (3,9).
Viburnum rufidulum Raf. Rusty blackhaw, viburnum (5,7).

Summer Flora of Horseshoe Bend

Valerianaceae

Valerianella radiata (L.) Dufr. Corn-salad (0).

Cucurbitaceae

Melothria pendula L. Creeping cucumber (0,1).

Sicyos angulatus L. Bur-cucumber (0).

Campanulaceae

Lobelia cardinalis L. Cardinal flower (0,6).

L. puberula Michaux. Hairy lobelia (0,6).

Specularia perfoliata (L.) A. DC. Venus' looking-glass (0).

Asteraceae (Compositae)

Achillea millefolium L. Common yarrow (0).

Ambrosia artemisiifolia L. Common ragweed (0).

Antennaria plantaginifolia (L.) Richardson. Plantain-leaf pussy-toes (0).

Aster divaricatus L. Heart-leaf aster (7).

A. pilosus Willd. Frostweed aster, white heath aster (2).

Bidens frondosa L. Devil's beggar-ticks (9).

Carduus discolor (Muhl. ex Willd.) Nuttall. Two-color thistle (2).

Coreopsis major Walter. Dye-flower coreopsis (4,5).

Elephantopus carolinianus Willd. Carolina elephant's-foot (6).

E. tomentosus L. Elephant's-foot (5).

Erechtites hieracifolia (L.) Persoon. Fireweed, American burnweed (4).

Erigeron annuus (L.) Persoon. Annual fleabane (0).

E. canadensis L. Horseweed (2).

E. strigosus Muhl. ex Willd. Rough fleabane (2).

Eupatorium capillifolium (Lam.) Small. Dog-fennel (2).

E. coelestinum L. Mistflower (0).

E. fistulosum Barratt. Joe-pye-weed (0,6).

E. purpureum L. Purple joe-pye-weed (7).

E. serotinum Michaux. Late thoroughwort, late eupatorium (2).

Gnaphalium obtusifolium L. Rabbit tobacco, fragrant cudweed (2).

G. purpureum L. Purple cudweed (0,1).

Helenium amarum (Raf.) H. Rock. Bitterweed, bitter sneezeweed (0).

Helianthus tomentosus Michaux. Hairy sunflower (4,5).

Heterotheca graminifolia (Michaux) Shinnars. Grass-leaf golden aster (4).

Hieraceum gronovii L. Rattlesnake-weed (5,7).

Krigia dandelion (L.) Nuttall. False dandelion (5).

Lactuca canadensis L. Wild lettuce (0).

Liatrix squarrosa (L.) Michaux. Blazing-star (7).

Mikania scandens (L.) Willd. Climbing hempweed (3,6).

Polymnia wedalia L. Bear's-foot (7).

Pyrrhopappus carolinianus (Walter) DC. Carolina false dandelion (0).

Rudbeckia fulgida Aiton. Black-eyed susan (0).

R. hirta L. Hairy coneflower (0).

Senecio glabellus Poiret. Butterweed, cress-leaf groundsel (6).

S. smallii Britton. Small's groundsel (7).

- Silphium compositum* Michaux. Rosinweed (4).
S. dentatum Ell. Starry rosinweed (4,5).
Solidago nemoralis Aiton. Gray goldenrod (2).
Solidago spp. Goldenrods (2,3).
Sonchus oleraceus L. Common sow-thistle (0).
Taraxacum officinale Wiggers. Common dandelion (0,1).
Verbesina alternifolia (L.) Britton ex Kearney. Crownbeard (0).
V. occidentalis (L.) Walter. Wingstem crownbeard (2).
V. virginica L. Tickweed, Virginia crownbeard (0).

LITERATURE CITED

- Earle, F. S. 1902. The flora of the metamorphic region of Alabama. Auburn Univ. Agr. Exp. Sta. Bull. 119.
- Fenneman, N. M. 1938. Physiography of the Eastern United States. McGraw-Hill, New York. 689 pp.
- Fernald, M. L. 1950. Gray's New Manual of Botany, 8th ed. American Book Company, New York. 1362 pp.
- Harper, R. M. 1943. Forests of Alabama. Geol. Surv. Ala. Monograph 10. 230 pp.
- McVaugh, R. 1943. The vegetation of the granitic flat-rocks in the southeastern United States. Ecol. Monogr. 13:119-166.
- Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. Manual of the Vascular Flora of the Carolinas. University of North Carolina Press, Chapel Hill. 1183 pp.
- Small, J. K. 1933. Manual of the Southeastern Flora. University of North Carolina Press, Chapel Hill. 1554 pp.
- Weed Science Society of America. 1971. Composite list of weeds. Weed Sci. 19:435-476.

OVARIAN DEVELOPMENT OF SMALLMOUTH BASS IN
PICKWICK RESERVOIR^{1,2}

Wayne A. Hubert and Vester P. Mitchell, Jr.

*Division of Water Resources
Tennessee Valley Authority
Muscle Shoals, AL 35660*

Abstract. The sexual maturity and seasonal ovarian development of 202 smallmouth bass from Pickwick Reservoir were evaluated. Most fish did not mature sexually until their fourth year, although a few were sexually mature at three years. Ova, in sexually mature individuals, were found in all stages of development. Two distinct size groups of ova were observed prior to spawning; only a portion of the larger group ripened fully at any one time. Following the spawning season residual ova were resorbed during the summer, and renewed ovum development was observed in September. Throughout the ova maturation process larger fish were advanced over smaller, but still sexually mature ones. Smallmouth bass produced larger ova, but a smaller number per unit of total length, than either largemouth or spotted bass.

INTRODUCTION

The Tennessee River drainage forms the southern periphery of the natural range of smallmouth bass, *Micropterus dolomieu*. Within the Tennessee Valley, Pickwick Reservoir, particularly the headwaters (Wilson Dam Tailwater), is known for the large size and quantity of its smallmouth bass. The Tennessee Valley Authority is studying the fishery of Pickwick Reservoir to identify management techniques for enhancing other smallmouth bass fisheries. Life history information is being gathered as part of the project.

Despite extensive biological studies, no published information is known on ovarian development of the smallmouth bass, although it has been described for two closely related species, the largemouth bass, *Micropterus salmoides* (James 1946, Kelley 1962) and the spotted bass, *Micropterus punctulatus* (Vogele 1975). Limited work has been done on smallmouth bass fecundity. One such study on Pickwick Reservoir bass has shown that the estimated "effective fecundity," i.e., the number of potentially mature ova available for spawning (Ruelle 1977), ranged from 2,600 to 27,200 per year (Hubert 1976). It was observed that effective fecundity could be predicted from knowledge of total length (TL),

¹Manuscript received 16 March 1979; accepted 10 April 1979.

²This article is a Government publication and not subject to copyright.

weight, or age of Pickwick Reservoir fish. The present study was performed as an extension of the fecundity research.

METHODS

Ovaries were taken from 202 individual female smallmouth bass collected from 1972 to 1975 by angling and electrofishing during all months. Field and laboratory methods employed in the study are described by Hubert (1976). Normal probability paper was used (Harding 1949) to evaluate the ova diameter frequencies for the proportion of the samples in each modal group, the means of the modal groups, and the points of inflection between modal groups. Gonadal somatic indices (GSI) were calculated and developmental stages of the ova were identified according to James' (1946) five stages of ova maturation:

- Stage I: youngest oocytes
- Stage II: vacuolization of the cytoplasm
- Stage III: beginning of yolk deposition
- Stage IV: the mature ovum
- Stage V: egg resorption (partly and completely spent ovaries)

RESULTS AND DISCUSSION

Just prior to spawning, sexually mature smallmouth bass contained ova in all stages of development. Ovum diameter reached 3.13 mm. As with other fish species (see Clark 1934, Hickling and Rutenburg 1936, Kelley 1962, Vogeles 1975) it was possible to categorize sexually mature smallmouth bass according to the stages of ova development and the ova diameter frequency distributions observed prior to spawning. Eight of eleven smallmouth bass collected in April and determined to be three years old (241-305 mm TL) were judged to be sexually immature despite the presence of ova. The eight immature females had a unimodal ova diameter frequency distribution with no ovum greater than 1.30 mm. No ova beyond Stage II were observed in these immature fish. An example of the ova diameter frequency distribution of an immature, three-year-old smallmouth bass is shown in Figure 1.

All four-year-old smallmouth bass collected from Pickwick Reservoir ($n = 12$) were sexually mature. The smallest female judged to be sexually mature was 257 mm (TL) and three years old. The ova diameter frequency distribution of sexually mature smallmouth bass was bimodal (Figure 1). Just prior to spawning the largest modal group was composed of Stage III and IV ova. Ova diameters in the largest mode ranged from 1.31 to 3.13 mm in April. The largest mode made up an average of 54 percent of the ova, but a range of 29-65 percent was observed in samples from individual fish. The smaller modal group found in sexually mature fish collected in April was composed of Stage I and II oocytes.

The mean ovum diameter in the largest mode of sexually mature females ($n = 26$) ranged from 1.75 to 2.41 mm. The mean ovum diameter of the largest modal group was observed to be at least partially associated with the length, weight, and age of the fish (Hubert 1976). Statistically significant ($\alpha = 0.05$) correlations were observed with total length ($r = 0.40$), and age ($r = 0.47$). To illustrate this association,

Ovarian Development of Smallmouth Bass

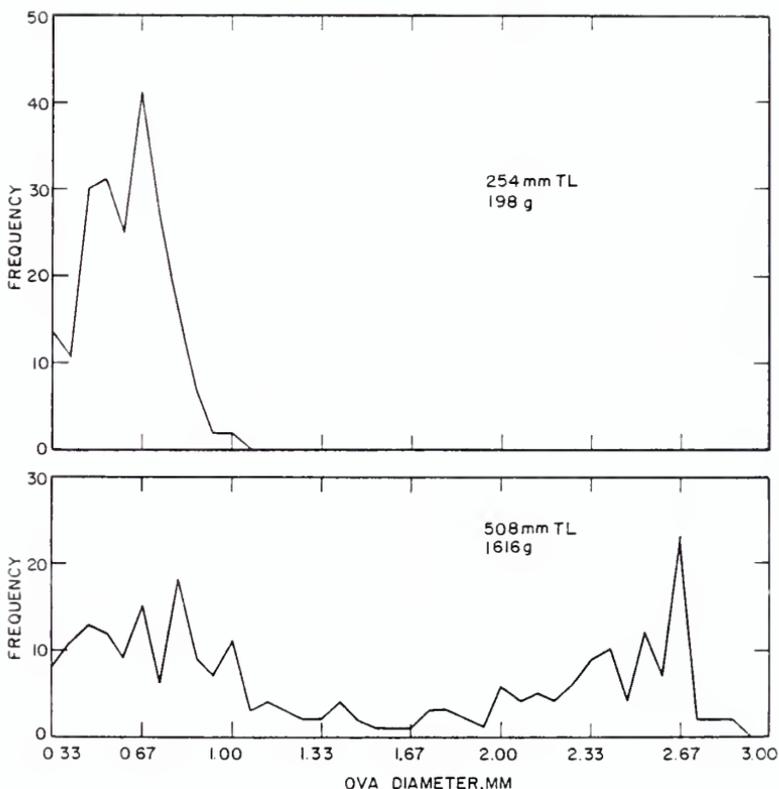


Figure 1. Ovum diameter (mm) frequency distribution of a sexually immature smallmouth bass (total length = 254 mm, weight = 198 g) collected April 15, 1975, and of a sexually mature smallmouth bass (total length = 508 mm, weight = 1616 g) collected April 26, 1975.

mean ova diameters of 30 sexually mature fish collected in April 1974 were plotted against total length of the fish (Figure 2).

A sharp demarcation was observed between the two modal groups of sexually mature fish collected in April. A trend toward an increase in the point of inflection was observed to occur with increase in fish size. Of 30 specimens collected in April 1974, the point of inflection was estimated to occur at 1.56 mm in 17 of the fish, but a range from 0.93 to 1.63 mm was observed.

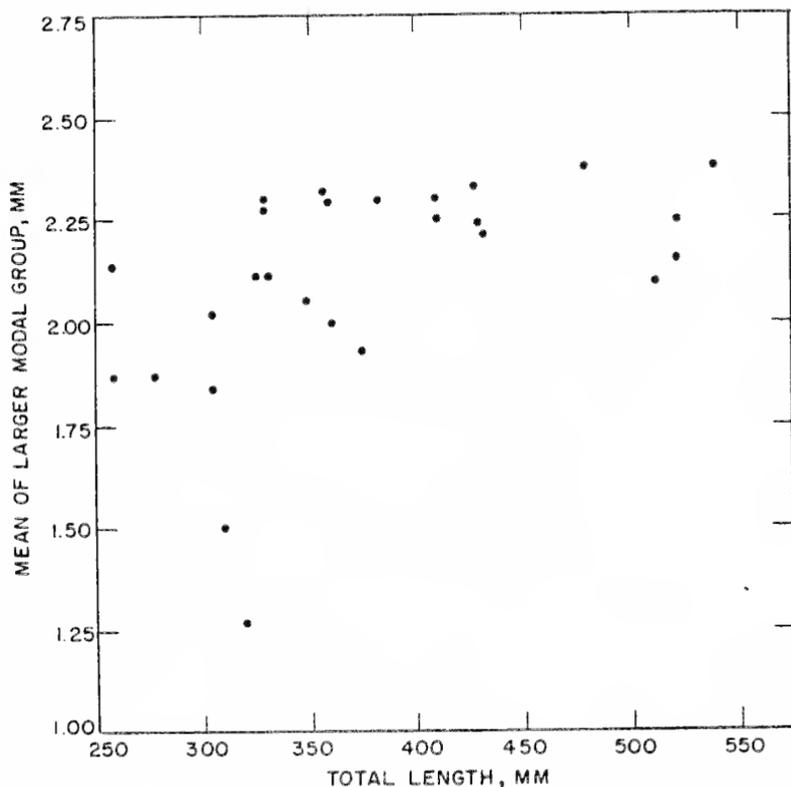


Figure 2. The mean diameter (mm) of ova in the largest modal group versus total length (mm) of 30 smallmouth bass collected in April 1974.

Seasonal Ovarian Development

Gonadal somatic indices (GSI) were calculated for 135 sexually mature fish collected in 1974 (Figure 3). The ovaries reached their maximum proportionate size (6.0 percent) in April just prior to spawning. By June the mean GSI was only 0.6 percent and it declined further to 0.4 percent in July. During fall the mean GSI began to increase slightly. Over winter and spring the proportionate size of the ovaries increased more than tenfold to the spring maximum. Changes in GSI correspond with observations of ova diameter frequency and with stages of ovum maturity. The maximum GSI's were attained in April when ova of the largest modal group were becoming fully ripe.

Ovarian Development of Smallmouth Bass

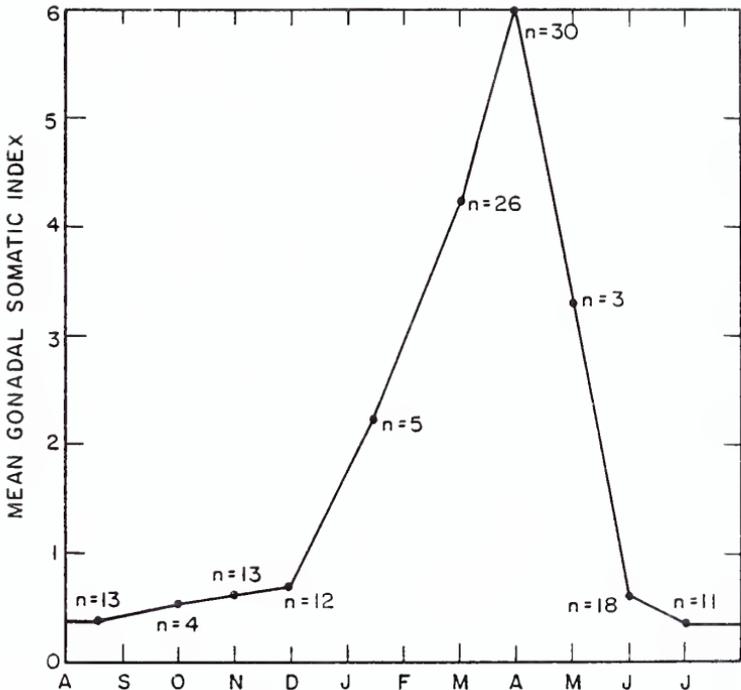


Figure 3. Mean gonadal somatic indices (GSI) of smallmouth bass at various times of the year.

Fully ripened ova appear translucent and contain a distinct yellow oil globule. The fully ripened ova ranged from 2.67 to 3.13 mm and were the largest ova of the most advanced modal group. They formed only a small portion (< 10 percent) of the ova in the largest modal group in fish collected during late April and May. Only a portion of the potentially mature ova appeared fully ripe at one time. This observation suggested that disjunctive or fractional spawning occurred in this smallmouth bass population. This was corroborated by Inslee (1975) who observed that hatchery fish spawned up to eight separate times during one spawning season.

Seventeen of eighteen females collected in June contained a unimodal ova diameter frequency distribution of small (< 1.61 mm), yolk-lacking ova. By June all ova of the largest modal group had either been spawned or resorbed by these fish. A large female (508 mm TL), collected on June 29, 1975, contained residual ova of both modal groups. The remaining ova in all June samples showed substantial atresia and

strongly adhered to the connective tissue within the ovary. Observations of July and August ovary collections ($n = 24$) indicated that the entire complement of residual ova was resorbed. The Stage I and II ova, as well as the potentially mature ova that were not spawned, appeared to disintegrate during the summer.

September samples indicated renewed ovum development; Stage I and II oocytes were distinct. By November numerous Stage III ova were observed in some of the samples. Frequency distributions of ova diameters were calculated for eight fish (324-525 mm TL) collected November 1974. The five smallest fish (324-400 mm TL) exhibited a unimodal frequency distribution with ova up to 1.07 mm while the three largest specimens (443-525 mm TL) exhibited bimodal distributions with ova up to 3.00 mm (Figure 4). A similar observation was made on December specimens; fish under 400 mm TL showed a unimodal distribution, whereas larger fish showed bimodal distributions. These observations indicated that the largest mode of Stage III and IV ova began to form in the fall in females over 400 mm TL. Between December and March a large mode was formed in all sexually mature fish, but the mean ovum diameter of fish less than 400 mm was smaller than that in large fish. Throughout the ovum maturation process, large fish showed more advanced ova development than smaller sexually mature fish.

Comparison with Other Basses

Largemouth bass and spotted bass inhabit Pickwick Reservoir in addition to the smallmouth bass. Comparison of the frequency distributions of ova diameters among the three bass species revealed numerous similarities. All three species have a bimodal frequency distribution in sexually mature fish prior to spawning (Kelley 1962, Vogele 1975), with indications that only the most advanced modal group was composed of Stage III and IV ova. Seasonal ovarian development followed a similar pattern in all three species (James 1946, Vogele 1975).

Differences in ovum development occurred among the three species relative to their effective fecundity and the mean ovum diameter of the largest modal group. Based on previously published observations (Kelley 1962, Vogele 1975, Hubert 1976), the effective fecundity and mean ovum diameter of the largest mode were compared (Table 1). An inverse relation was observed between the fecundities and the mean diameters of ova in the largest mode among the three *Micropterus* species. Smallmouth bass produced the smallest number of ova, but the mean diameter of the largest mode was the greatest of the three species. Largemouth bass produced the largest number, but the smallest size ova of the three species.

SUMMARY

The Pickwick Reservoir smallmouth bass population exhibited the following characteristics:

1. A few bass became sexually mature at three years of age, but most reached sexual maturity only in their fourth year.

Ovarian Development of Smallmouth Bass

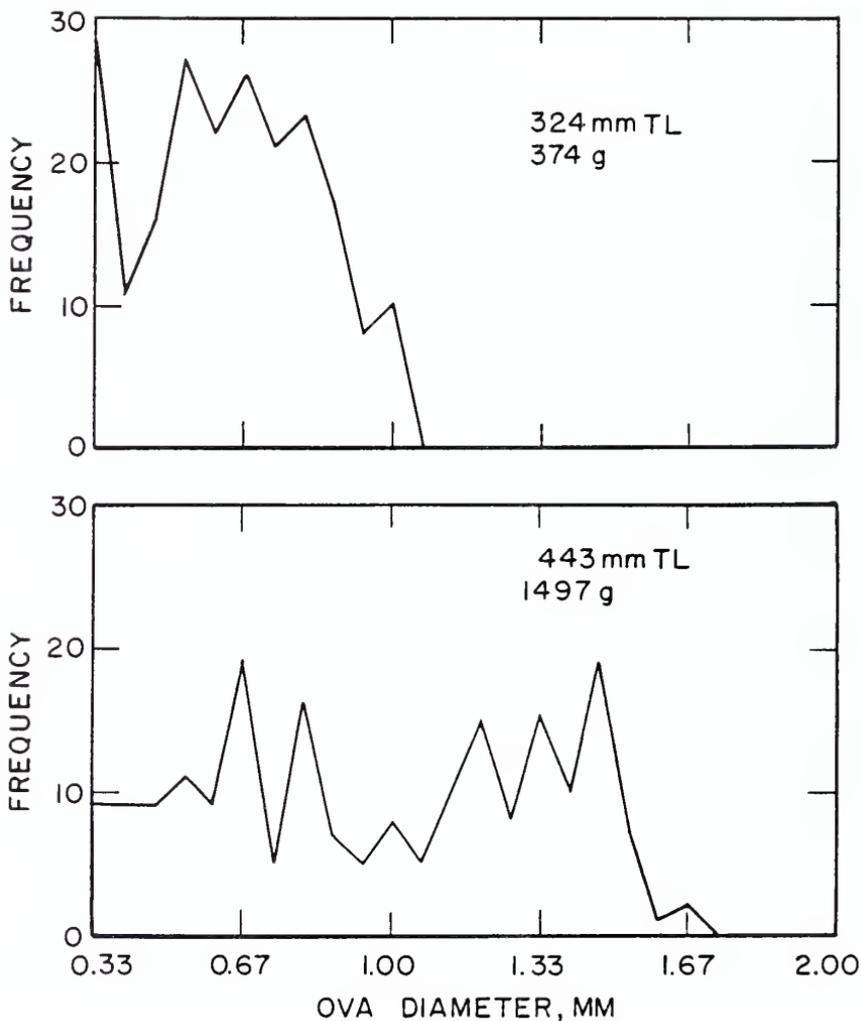


Figure 4. Ovum diameter (mm) frequency distribution of a small sexually mature smallmouth bass (total length = 324 mm, weight = 374 g) and of a large sexually mature smallmouth bass (total length = 443 mm, weight = 1497 g) collected November 1, 1974.

Table 1. Comparison of estimated fecundity at a given length and the range of ova diameters in the most advanced modal group prior to spawning for smallmouth, spotted, and largemouth bass based on Hubert (1976), Vogele (1975), and Kelley (1962).

Total Length	Estimated Fecundity		
	Smallmouth	Spotted	Largemouth
350	7,300	7,500	13,400
400	11,700	17,300	24,500
450	16,100	27,200	49,000
Range in ova diameters (mm) in most advanced modal group prior to spawning	1.31-3.13	1.25-2.10	0.75-1.56

2. The smallmouth bass produced more ova than actually reached maturity. Two distinct modes composed of all stages of ovum development were observed prior to spawning, but only a portion of the largest mode became fully ripe at one time.
3. Following the spawning season residual ova were resorbed during the summer; renewed ovum development was observed in September.
4. Throughout the ovum maturation process, large females were advanced over smaller, sexually mature fish. Larger females produced larger ova and greater numbers of ova than did smaller females.
5. Smallmouth bass produced larger ova, but a smaller number per unit of total length, than either largemouth bass or spotted bass from other localities.

LITERATURE CITED

- Clark, F. N. 1934. Maturity of the California sardine (*Sardina caermulea*) determined by ova diameter measurements. California Division of Fish and Game, Fisheries Bulletin Number 42. 49 pp.
- Harding, J. P. 1949. The use of probability paper for the graphical analyses of polymodal frequency distributions. Journal of the Marine Biology Association, United Kingdom. 28:141-153.
- Hickling, J. F. and E. Rutenburg. 1936. The ovary as an indicator of spawning period of fishes. Journal of the Marine Biology Association, United Kingdom. 21:311-317.

Ovarian Development of Smallmouth Bass

- Hubert, W. A. 1976. Estimation of the fecundity of smallmouth bass, *Micropterus dolomieu* Lacepede, found in the Wilson Dam Tailwaters, Alabama. *Journal of the Tennessee Academy of Science* 51(4):142-144.
- Inslee, T. D. 1975. Increased production of smallmouth bass fry. Pages 357-361 in R. H. Stroud and H. C. Clepper: *Black Bass Biology and Management*. Sport Fishery Institute, Washington, D.C.
- James, J. F. 1946. Histology of gonadal changes in the bluegill *Lepomis macrochirus*, Rafinesque, and the largemouth bass, *Huro salmoides* (Lacepede). *Journal of Morphology* 79(1):63-86.
- Kelley, J. W. 1962. Sexual maturity and fecundity of the largemouth bass, *Micropterus salmoides* (Lacepede), in Maine. *Transactions of the American Fisheries Society* 91(1):23-28.
- Ruelle, R. 1977. Reproductive cycle and fecundity of white bass in Lewis and Clark Lake. *Transactions of the American Fisheries Society* 106(1):67-76.
- Vogele, L. E. 1975. Reproduction of spotted bass, *Micropterus punctulatus*, in Bull Shoals Reservoir, Arkansas. *United States Fish Wildlife Service Technical Paper* 84. 24 pp.

INSTRUCTIONS TO AUTHORS

Editorial Policy:

Publication in the *Journal of the Alabama Academy of Science* is restricted to active members. Subject matter should be from original research in one of the eleven disciplines which comprise the sections of the Academy: Biological Sciences; Chemistry; Geology; Forestry, Geography, and Conservation; Physics and Mathematics; Industry and Economics; Science Education; Social Sciences; Health Sciences; Engineering; Anthropology. Timely review articles of exceptional quality will be considered.

Regular articles are published in approximate order of acceptance. Each manuscript received is sent to at least two qualified reviewers (the Editor may serve as a reviewer when subject matter is in his field), and copies of their comments and suggestions are sent to the author. Upon acceptance of a paper, the author receives a galley proof and a reprint order form.

Manuscripts:

Since the Academy encompasses many disciplines, no standard format for manuscripts is feasible. Each author should follow the form and style of a major quality journal in the author's field. Manuscripts in the Biological Sciences may follow suggestions of the AIBS STYLE MANUAL.

Manuscripts should be double-spaced throughout (including title, footnotes, legends, literature cited, etc.) allowing 1-inch margins. The original and two copies should be submitted to the Editor. Papers which are unreasonably long and verbose, such as uncut theses or reviews, will be returned. Number all pages.

Manuscripts should be typewritten in the following order: title, author's name, author's affiliation and address including zip code, abstract (if author desires), text (with proper headings), and literature cited.

Titles:

Make titles short but informative. Do not abbreviate.

Abstracts:

Authors may include an abstract with full-length articles if desired. This should come before the main body of text and should not exceed 200 words.

All abstracts of papers presented at the annual meeting will be published if submitted on time and in proper form to the Editor.

Instructions to Authors

Instructions relating to abstracts are mailed to each member prior to the annual meeting.

Headings:

Use headings and subdivisions where necessary for clarity. Common headings for research papers are: Introduction (usually includes a short literature review), Procedure (or Materials and Methods), Results, Discussion, Conclusions, and Literature Cited. Others are more appropriate for certain subject matter areas. Primary headings should be in all-caps and centered on the typed page; subdivisions should be italicized (underlined) and placed at the margin.

Footnotes:

Avoid excessive use of footnotes. Where few are used, number consecutively and place at bottom of page where cited. Where large numbers are necessary, list them consecutively at the end of the manuscript under the heading, FOOTNOTES.

Illustrations:

Submit *original* inked drawings (graphs and diagrams) or clear black and white glossy photographs. Width must be 5 1/2-6 inches and height must not exceed 8 inches. Illustrations not conforming to these dimensions will be returned to the author. Designate all illustrations as figures (abbreviate, Fig.), number consecutively, and cite all figures in text. Type figure captions on a *separate* sheet of paper. Send one extra set of illustrations for review purposes; xeroxed photographs are unsatisfactory. Use lettering which will still be legible after a 30% reduction.

Tables:

Place each table on a separate sheet and type the caption, or title, directly above it. Number tables consecutively. Use symbols or letters, not numerals, for table footnotes. Cite all tables in the text.

Literature Cited:

Only references which are cited in the text should be listed under *Literature Cited*. Do *not* group references according to source (books, periodicals, newspapers, etc.). List in alphabetical order of senior author names. Cite references in the text by number (preferred) or by author-date. Do not cite personal communications or unpublished data in *Literature Cited*; these may be placed in the text. Consult a recent issue of the Journal for satisfactory styles used in various subject matter areas.

NOTES

NOTES

THE JOURNAL
OF THE
ALABAMA ACADEMY
OF SCIENCE

AFFILIATED WITH THE
AMERICAN ASSOCIATION FOR THE
ADVANCEMENT OF SCIENCE

VOLUME 50

JULY, 1979

NO. 3

EDITOR:

W. H. Mason, General Biology, Auburn University, Auburn, AL 36830

ARCHIVIST:

R. G. Eaves, Department of History, Auburn University, Auburn AL 36830

EDITORIAL BOARD:

R. T. Gudauskas, Chairman, Department of Botany and Microbiology, Auburn University, Auburn, AL 36830

E. A. Curl, Department of Botany and Microbiology, Auburn University, Auburn, AL 36830

W. W. Paulder, Department of Chemistry, University of Alabama, University, AL 35486

ADVISORY BOARD:

W. L. Alford, Auburn University

Walker H. Land, Jr., IBM

Charles Baugh, Univ. South Alabama

H. S. Marks, N. E. St. Jr. Col.

G. F. Brockman, Univ. Ala., B'ham

M. Miller, Univ. South Alabama

R. J. Fornaro, Univ. South Alabama

W. W. Paudler, UA, Tuscaloosa

A. Wayne Lacy, Auburn Univ., Mtgy.

Dan Whitson, Decatur

E. M. Wilson, Univ. South Alabama

The Journal is the official publication of the Alabama Academy of Science, and is indexed in Biological Abstracts, Chemical Abstracts, America: History and Life, and Historical Abstracts.

Publication and Subscription Policies

Submission of Manuscripts. Submit all manuscripts and pertinent correspondence to the EDITOR. Each manuscript will receive two simultaneous reviews. For style details, follow Instruction to Authors, J. Ala. Acad. Sci. 50:96-97, 1979.

Reprints: Requests for reprints must be addressed to authors.

Subscriptions and Journal Exchanges: Address all correspondence to the CHAIRMAN OF THE EDITORIAL BOARD.

Advertising, News Releases: Advertisements and news releases will not be published in the Journal.

CONTENTS

KEYNOTE ADDRESS	98
---------------------------	----

ABSTRACTS

Biological Sciences	104
Chemistry	118
Geology	127
Forestry, Geography, and Conservation	135
Physics and Mathematics	140
Industry and Economics	146
Science Education	154
Social Sciences	154
Health Sciences	157
Engineering	172
Anthropology	175

MINUTES OF ANNUAL BUSINESS MEETING	178
--	-----

KEYNOTE ADDRESS

THE HONORABLE RONNIE G. FLIPPO
ALABAMA ACADEMY OF SCIENCE
FLORENCE, ALABAMA
MARCH 31, 1979

Thank you for that fine introduction. I am delighted to be with you today. It is not too often that I have the opportunity to speak to a group like this where there are both representatives of the scientific community and students training for careers in science.

I want to take advantage of this opportunity and discuss with you some of my hopes and concerns about the status of research and development activities in our country.

I am a member of the Committee on Science and Technology in the House of Representatives which oversees the broad range of research and development issues in our Nation. I declared my intentions to seek membership on this important committee during the week after my election in 1976. I worked hard to get it because I think it is important for the Congressman from the Fifth Congressional District in Alabama to be on this committee.

Located in the fifth congressional district is one of the largest concentrations of scientific talent and expertise in the country. There are very few areas of our country where there is a scientific community that deals with a range of research and development activities as broad as those in North Alabama.

The Marshall Space Flight Center is the most important component of our national space program. The men and women of Marshall have been the prime factor in the success of our national space program for many years.

The military and civilian efforts at Redstone Arsenal have been and will continue to be the cutting edge of research and development in national defense programs. The programs at Redstone are the mainstay of our national defense effort.

The space and rocket development in our area have captured the imagination of mankind.

Agricultural research does not always get much public attention. However, North Alabama has an international reputation in agricultural research. The TVA facilities in Muscle Shoals have been responsible for virtually all of the breakthroughs in fertilizer research and development in our lifetime. TVA sponsored R & D has been responsible for about 75 percent of all the patents granted in the fertilizer industry.

A byproduct of all these R & D programs not widely recognized or appreciated has been the tremendous concentration of managerial talent located in our state. The men and women of our region are well known in government and industry for their ability to manage large and complex

Ronnie G. Flippo

high technology programs. This expertise is a precious national asset that will play an important role in solving the complex problems we face today.

I am proud to represent this community of scientists as a member of the Science and Technology Committee.

I have found out that the easiest way to trigger a debate in committee hearings or in a conversation with scientists is to state that "American technology is in good shape." This statement triggers an outpouring of statistics and complaints.

You can look at the figures for research and development and see that they are at the highest levels ever. The figures also show that the number of scientists employed in our economy is at the highest level ever.

The figures are accurate. Data shows that this nation will spend more than fifty billion dollars on R & D in 1979. A higher level of spending is projected for next year. Approximately half of the fifty billion dollars will be funded by the federal government. And about half of the federally funded R & D will be for defense related activities.

President Carter has proven that he recognizes the need for R & D. Each of his budgets has included real increases in R & D.

As a result of the increase in overall federal funding for R & D, there will be 600,000 scientists and engineers employed in R & D activities in all sectors of the economy in 1980. These figures may be misleading. We may be spending a record amount of money on R & D, but as a percentage of GNP, spending on R & D is declining. Furthermore, the federal R & D budget is not well managed, coordinated, or evaluated.

The truth is that there are clear signals that this nation's commitment to technological development and change is diminishing.

I would like to think that American technology is not in a decline because it is so important to the welfare of all of us. Although it is not easily measured, we know that there is a strong, positive correlation between research and development and economic growth. There can be no doubt that the economic success of our country is directly related to our investment in technological development.

I would like to think that American technology is not on the skids because we need it now more than ever. Without a successful national R & D effort, we will be unable to overcome the tremendous challenges facing our country. The dollar will continue to remain on the list of endangered species. Our national security will be in jeopardy. This nation will not be able to overcome the problems of the energy crunch or inflation or deal with declining worker productivity.

The mood among the general public and industrial research managers is not favorable towards investment in new technology.

Keynote Address

The majority of Americans recognize the important role technology has played in our society. In general, the public supports R & D. But, there is a growing public concern that technological innovation cannot be controlled, may not always be safe, and is too expensive.

Public opposition has been the key factor in the decline of the nuclear energy industry and the cancellation of certain defense projects. If the public or government stops a project on the merits of the case, the logic is obvious and the decision correct. However, when a new technology is stifled as a result of hysteria, halftruths, or ignorance then we will someday regret those actions.

The mood among industrial research managers is bleak. They believe that America's technological superiority of the 1950's and 1960's is vanishing. This decline is attributed to wrongheaded federal policy, neglect, uncertain business conditions, and shortsighted corporate management.

Industrial research has suffered some severe setbacks in the past decade. The abrupt and dramatic reduction in the NASA budget after the moon landing has been a major contributing factor to industrial R & D. Another has been the impact of the energy crisis on the economy. The prevailing tendency in the corporate executive suites has been to forget the long range and aim only for the short run payoff. This trend has stifled innovation and discouraged initiative.

These disturbing research trends have attracted attention at the highest levels in government.

Next week the Committee on Science and Technology will hold hearings on the status of the federal role in R & D. We will be seeking information from the executive branch about how the federal R & D budget is formulated, managed, and correlated with the needs of our society. The members of the Committee intend to find out how we can develop a federal policy and budget that will address the pressing needs of our country.

The President is also moving to address the crisis in technology. He has ordered a massive review of the role government plays in helping or hindering the health of industrial innovation. The President's concern is underscored by the fact that it is organized as a domestic policy review project. This is the highest sort of attention a problem can receive within the executive branch.

This study, which will be completed in the near future, is headed by the Secretary of Commerce. It involves thirty federal agencies and many advising groups from private industry, labor, universities, and public interest groups. I expect many practical recommendations from this study to make our industries more innovative.

The President has also established a Productivity Council. This council is examining how science and technology can improve federal, state, and local government productivity, as well as the productivity of the private sector.

Technological progress does not just happen. It requires planning and investment.

Americans have not lost their ability to innovate. But there are restrictive elements at work.

I hope the attention that my committee and the President's policy review is focusing on science and technology will lead the way to a more productive future for all of us.

The United States has lived through two periods of technical prosperity since the 1940's. The investments this country made in the aerospace and the nuclear energy industries produced massive benefits all of us enjoy.

Our next logical frontier is energy, yet, there is no plan, no commitment, and no real budget to move ahead on this front. Many have been watching the Department of Energy hoping that this agency will take up the slack in R & D vacated by NASA and the nuclear industry.

This is why I voted to create the Department of Energy.

DOE has been in existence for over a year, but it is hobbling along the best that it can waiting for leadership and looking for clear signals as how to best proceed for the future.

The DOE strategy for the short run has been based on a combination of conservation and regulation. These policies have been designed to insure adequate supplies of energy at fair and equitable prices.

The recent events in Iran have demonstrated the inadequacy of this approach. The cutoff of oil from Iran, which only accounts for a very small percentage of our imported oil, has created turmoil in our energy markets.

Long lines at filling stations, bans on weekend driving, Sunday closing of stations, and even gas rationing may soon be a way of life in the U.S.

This may be the way of life in our country, not necessarily because of fuel oil shortages, but because of federal regulations.

These regulations prohibit any return on new refining investments. The regulations only permit depreciation of invested capital and interest on borrowed funds to be passed on to consumers. Consequently, investment in refinery facilities has been discouraged. Soon the demand for gasoline may exceed the ability of refiners to manufacture it.

Thus, the immediate future will be spot shortages, the allocation of available supplies, and steadily rising prices.

We need to develop long range supplies of energy that will place a cap on the price of oil and electricity. This nation needs an energy

Keynote Address

program that will remove our dependency on foreign bankers and weak and vulnerable allies.

This should be the goal of the energy department.

The DOE budget does not reflect the urgency of our energy predicament. The budget authority requested by the President for the Department of Energy in 1980 amounts to \$8.4 billion. This is a tremendous amount of money, but it is deceiving. This figure includes three billion dollars for Atomic Energy Defense Activities and 1.3 billion dollars for conservation, regulatory activities, and administration. It only includes four billion dollars for energy technology, development, and deployment.

In the long run our energy options are clear. We can only depend on nuclear fission, nuclear fusion, and solar energy.

We need to be making every possible effort to develop these energy resources through a vigorous R & D program. It will be expensive, but necessary if we are to continue our way of life.

The need to utilize our technological abilities to develop alternative energy sources has clearly shown the need for substantive action in this area. This is why I have introduced the Solar Power Satellite Research, Development and Evaluation Program legislation. The bill would begin a program to determine the economic and environmental feasibility of solar power satellites.

We need to correct this technology verification program if we are to have the information we need to make intelligent decisions to meet our future energy needs. Solar power satellites show great promise as a means to collect the infinite energy of the Sun in space and beam it back to Earth. Solar energy may prove to be a clean, inexpensive and inexhaustible energy resource for generations to come. It is through our scientific and technological abilities that we can solve a complex problem such as energy and all mankind will reap the benefits.

We have reached a point where R & D is not just necessary to continue our economic growth and superiority. It is necessary for the survival of our society.

The expenditure of large sums for R & D have not been unusual in our country. The nation has poured money into R & D in the past to increase our productive capacity in WW II, to develop our nuclear industry, and to land on the moon.

Over the past twenty years, we have expended over \$200 billion in incentives to stimulate energy production.

The American people will support a major R & D effort to find alternative energy resources. The President and his officials in DOE must first clearly identify the goals and work with the Congress and the scientific community to gain widespread public support for these

Ronnie G. Flippo

goals. The American people will support the necessary R & D program if they fully understand its objectives and goals.

Those of you here today are a positive force in our community to shape opinions and inform others of how we all gain from the research and development which is performed in this country. Many of you will actively participate in this valuable scientific and technological work. But we all have a role to play as informed citizens with a clear understanding of the role science should have in solving the problems of today and achieving the dreams of tomorrow.

ABSTRACTS

Papers presented at the 56th Annual Meeting
University of North Alabama
Florence, Alabama
March 29-31, 1979

BIOLOGICAL SCIENCES

PRELIMINARY INVESTIGATION OF THE EFFECTS OF GA-7 ON THE GROWTH OF A DESMID

Margaret Miller. Dept. of Biology, Univ. of S. Ala., Mobile, AL 36688.

In preliminary studies, the plant hormone, gibberellic acid 7 (GA7) has been found to effect the growth of a freshwater desmid, *Selenastrum bibratianum*. Five different concentrations of GA7 (5, 15, 20, 25 & 35 $\times 10^{-6}$ g/ml) were added to axenic cultures of *Selenastrum*. In every case, the growth of *Selenastrum* was stimulated by the addition of GA7 to the culture media with the greatest stimulation of growth obtained when GA7 was added at the 20 $\times 10^{-6}$ g/ml concentration.

EFFECT OF SACCHARIDES ON POLYPHENOL OXIDASE FROM POTATOES

Victor Chan and John M. Frazer. Dept. of Chemistry, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Polyphenol oxidase is a ubiquitous, copper-containing enzyme which catalyzes the oxidation of ortho-diphenols to ortho-quinones. This activity is responsible for the browning of fruit, formation of skin pigment, and the covalent crosslinking of proteins in the exoskeleton of insects and crustacea. The enzyme tends to lose activity readily, and our study has centered on defining conditions which stabilize or labilize the enzymatic activity. Sucrose, as a common reagent for stabilizing proteins, was the first additive employed; for comparative purposes, other sugars were also examined for their effect on polyphenol oxidase. Spectrophotometric assays (measuring the conversion of dihydroxyphenylalanine (DOPA) to dopaquinone at 475 nm) indicate that none of the sugars affected enzyme activity initially but upon incubation at different temperatures, the activity either increased or decreased, depending on the sugar and the time of incubation. A change in the number of active enzyme molecules appears responsible for these differences, because the K_{111} does not seem to be affected. At 50°C, sucrose is the most effective activator tested and galactose is the most effective inactivator; other sugars exhibit intermediate effects.

Abstracts

ATRAZINE LEVELS NECESSARY TO ADVERSELY AFFECT AQUATIC PLANTS IN CHESAPEAKE BAY

D. R. Forney and D. E. Davis. Dept. of Botany and Microbiology, Auburn Univ., Auburn, AL 36830.

The population of submerged plants in Chesapeake Bay has greatly declined over the past two decades. The Chesapeake is a highly diverse estuarine ecosystem, providing a broad range of growth conditions for these plants. Many factors may be involved in the population decline. It has been postulated that one of the factors may be agricultural chemicals which enter the Bay as run-off from surrounding farmlands. Due to its widespread use and relatively long persistence, the herbicide atrazine is of primary concern. Laboratory studies have been conducted to determine what atrazine levels in water inhibit the growth of submerged plants common in the Chesapeake Bay. *Elodea canadensis* is severely inhibited by atrazine levels in the range of 100 ppb. Further studies with other species, and also involving atrazine interactions with suspended particulate matter, as influenced by salinity, are planned.

TRANSFER OF CHLORAMPHENICOL RESISTANCE FROM *E. COLI* TO *PROTEUS VULGARIS*

Joey S. Rottman and R. Kyle Faust. Dept. of Biology, Huntingdon Col., Montgomery, AL 36106.

The role of antibiotics in producing resistant mutants of bacteria has been repeatedly investigated since 1952. In this study a species of bacteria not related to *E. coli* was made resistant to chloramphenicol through exposure to a mutant of *E. coli* resistant to this drug. The chloramphenicol-resistant mutant of *E. coli* was developed as the first phase of this experiment. Fifty plates of nutrient agar containing 100 micrograms of chloramphenicol per ml were streaked with *E. coli* previously cultured in Penassay Broth. Four of these plates demonstrated growth, and colonies were recultured in Penassay Broth. Through propagation of three or four successive *E. coli* transfers, the mutant retained its resistance to chloramphenicol. A sample of the resistant *E. coli* was mixed with *Proteus* in Penassay Broth. Following incubation, this mixed culture was streaked on nutrient agar containing 100 micrograms of chloramphenicol per ml. Upon plating, the mixed culture exhibited two distinctly different colonies, whereas the control of normal *Proteus* streaked under identical conditions showed no growth. Identification of resulting bacterial growth was accomplished using an Analytab Products Incorporate diagnostic strip. API confirmation of the colonies established that both *E. coli* and *Proteus* were present. Through use of normal sensitivity discs, it was found that the mutant *E. coli* were likewise resistant to Neomycin and Streptomycin. The results of these experiments indicate that the acquisition of chloramphenicol resistance by the *Proteus* occurred during exposure to the resistant *E. coli*. They further indicate that a transfer of a resistance factor occurred between the *E. coli* and the *Proteus*. Further investigation of resistance transfer is necessary, for with increasing use of antibiotics in today's society, man may well be creating potentially dangerous mutants of his own.

Abstracts

BETACYANIN CHEMICAL PROPERTIES AND DISTRIBUTION IN THE POKEBERRY (*PHYTOLACCA AMERICANA*)

Timothy Baltz and Jonathan Ford. Dept. of Chemistry, Birmingham-Southern Col., Birmingham, AL 35204.

To better characterize the distribution of pigments in the common pokeberry, the roots, stems, leaves, and berries were extracted with water and the extracts subjected to Sephadex column chromatography using phosphate buffers. Extracts of the berries and stems contained a pigment, homogeneous as indicated by paper chromatography in several solvent systems, which absorbed maximally at 538 nm, characteristic of betacyanin. Similar extracts of roots and leaves showed little apparent betacyanin content. Equilibrium dialysis was used to examine the protein binding properties of pokeberry betacyanin. A novel twelve-cell dialysis rotator, using Technilab 10 ml cells, was constructed. Dialysis against purified bovine serum albumin showed minimal dye binding at several pH's and protein concentrations. Betacyanin toxicity studies on rats and enzyme inhibition studies are currently in progress.

EFFECTS OF AMMONIUM SULFATE AND UREA ON THE GROWTH OF FIVE SPECIES OF ALGAE ISOLATED FROM LOWLAND RICE CULTURES

Michael R. Barrett. Dept. of Biology, Univ. of N. Ala., Florence, AL 35630.

Five species of Chlorophycean algae were isolated in unialgal cultures: *Bracteacoccus minor* (Chodat) Petrova, *Chlamydomonas* sp. 1, *Chlamydomonas* sp. 2, *Scenedesmus* sp., and *Uronema trentonense* Lee. Population growth curves were determined from cell counts and/or chlorophyll *a* measurements in unialgal cultures having 25 or 50 mg/l nitrogen as ammonium sulfate or urea added to a medium consisting of soil water extract plus nitrogen free Bold's Basal medium in a 1:1 ratio, and in control cultures without nitrogen added to the medium. Analysis of variance of these data indicated that a higher biomass occurred in cultures enriched with urea than in cultures enriched with an equivalent amount of nitrogen as ammonium sulfate in all species except *Chlamydomonas* sp. 2. There was no statistically significant difference between the growth in the two levels of ammonium sulfate or of urea. Biomass was significantly less in the controls than the ammonium sulfate enriched cultures from 14 days on and than in the urea enriched cultures from 10 days on. In general, photosynthetic activity appeared to reach a peak in the controls long before growth and cell division ceased.

UNCOMMON SHRUBS IN NORTH ALABAMA

Kenneth E. Landers, Thomas Cochis, and R. D. Whetstone. Dept. of Biology, Jacksonville State Univ., Jacksonville, AL 36265.

Uncommon to rare shrubs in North Alabama include *Amorpha schwerinii* Schneider, *Cornus alternifolia* L., *Diervilla rivularis* Gattinger, *Dryas*

Abstracts

palustris L., *Euonymus atropurpureus* Jacquin, *Fothergilla major* (Sims) Lodd, *Fothergilla gardenii* Murray, and *Hypericum dolabriforme* Ventenat. Other uncommon shrubs in the area are *Nestronia umbellula* Rafinesque, *Neviusia alabamensis* Gray, *Physocarpus opulifolius* (L.) Maximowicz, *Pyrularia pubera* Michaux, *Rhus vernix* L., *Ribes curvatum* Small, and *Robinia hartwigii* Koehne. Shrubs reported from the fewest sites in the area are *Andrachne phyllanthoides* (Nuttall) Mueller, *Clethra alnifolia* L., *Daubentonia punicea* (Cav.) DC., *Myrica heterophylla* Rafinesque, and *Rhus typhina* L.

SOME INTERESTING ALGAE FROM NORTHWEST ALABAMA

Arthur R. Koch. Dept. of Biology, Univ. of N. Ala., Florence, AL 35630.

Surirella spiralis Kuetz., and *Roya obtusa* (Breb.) W and G.S. West were found in a dripping seepage area adjacent to Cypress Creek in Lauderdale Co. *Urococcus insignis* (Hass.) Kuetz., *Cylindrocystis anomala* Taft, *Trentepohlia* sp., and *Sommerella* sp. were found on wet sandstone cliffs in the Dismal Gardens of Franklin Co. *Cycloneis annularis* Stokes, *Chrysostephanosphaera globulifera* Scherffel, a triflagellate *Uroglenopsis americana* (Calkins) Lemm., an unidentified species of *Phaeothamnion*, and *Ophiocytium arbuscula* (A.Br.) Rabh. are reported from a temporary woodland pool in Lauderdale Co.

AZALEA CULTURE IN NORTHEAST ALABAMA

Thomas Cochis, Kenneth E. Landers, and R. D. Whetstone. Dept. of Biology, Jacksonville State Univ., Jacksonville, AL 36265.

A kodachrome slide presentation was made showing the culture of azaleas in Northeast Alabama. Included in the presentation were varieties popular in the area, along with a discussion of cultural information such as (a) site selections, (b) soil preparation, (c) planting, (d) mulching, (e) minor element deficiencies, (f) pH control, (g) fertilizing, (h) watering, and (i) insect and disease problems.

SOME NOTES ON THE DISTRIBUTION OF *COTINUS OBOVATUS* RAF. (ANACARDIACEAE) IN ALABAMA

R. D. Whetstone, Kenneth E. Landers, and Thomas Cochis. Herbarium, Dept. of Biology, Jacksonville State Univ., Jacksonville, AL 36265.

Cotinus, or American Smoketree, has a documented, native distribution in Jackson, Madison and Morgan counties. Localities of occurrence in each of these counties reveal the following site conditions which ostensibly limit the distribution of this species. All sites studies are ridges and slopes. The ridges are unsheltered and mesoxeric. The slopes are unsheltered with an aspect of south to southwest and are also mesoxeric. Soils from three localities are not named but are given the label "limestone rockland." One may accurately infer from this that the soil is indeed rocky and that the rock type at each

Abstracts

locality is limestone. Soil pH was measured at each site and ranged from 7-7.5. *Cotinus* is most abundant in woodland openings along ridges or extremely rocky slopes where the rock type is limestone.

MYXOSOMA FUNDULI KUDO (MYXOSPORIDA) IN *FUNDULUS KANSAE*: ULTRASTRUCTURE OF THE PLASMODIUM WALL AND SPOROGENESIS

William L. Current. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

Plasmodium wall ultrastructure will be discussed and ultrastructural details of cell-to-cell interactions occurring within plasmodia will be used to reconstruct the major events of sporogenesis in *M. funduli*. Early sporogenic stages were located within immature plasmodia just interior to the zone of pinocytic canals. Later sporogenic stages, including mature spores, were concentrated in the center of mature plasmodia. Sporogenesis began within the envelopment of one generative cell, the sporont, by a second, non-dividing cell, the envelope cell. The sporont and its progeny proceeded through a series of divisions until 10 cells were present within the envelope cell. Once divisions were completed, the 10 cells became arranged into 2 identical spore-producing units, each consisting of 1 binucleate sporoplasm and 2 capsulogenic cells, all surrounded by 2 valvogenic cells. Later stages of spore development indicated that capsulogenesis, valvogenesis and sporoplasm maturation occurred concomitantly.

PREPARING AUDIO TUTORIAL MODULES FOR AN INTRODUCTORY BIOLOGY COURSE

O. A. Campbell and W. H. Mason. Biology Program, Auburn Univ., Auburn, AL 36830.

Audio tutorial instruction offers many advantages to the beginning biology student including visualization of lecture concepts and examples, aspect ratio, increased efficiency of content presentation, and an increase in understanding and retention of course content due to integration of lecture and laboratory skills and concepts. In order to develop effective teaching modules for such an introductory biology course it is useful to answer several questions concerning one's course. What is the nature of the audience you wish to reach? What are your module objectives--that is, what skills do you expect the students to be able to perform and which concepts do you expect them to understand upon completing the module? What is the scope and nature of the content you wish to present? And, finally, which strategy will you use to develop the audio and video presentation? Some basic strategy principles which might be helpful include: Keep it simple and direct; draw on all experiences of the audience; use humor--even absurdity--to illustrate examples; relate to the audience's experiences by using numerous examples and analogies.

Abstracts

HELMINTH PARASITES OF THE GRAY FOX (*UROCYON CINEREOARGENTEUS*) IN ALABAMA AND GEORGIA

Elton D. Rogers. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

The viscera of 30 gray foxes collected from seven counties in southeastern Alabama and one county in west Georgia were examined for helminth parasites. All foxes were caught by professional fur trappers during the 1977-1978 trapping season. Eleven different species of helminths were present in the sample of foxes. The incidence and worm burden of each species of parasite were calculated. *Physaloptera rara* was the most prevalent nematode with an incidence of 80%. The number of *Physaloptera* per fox ranged from 1 to 162. *Ancylostoma caninum* was second with an incidence of 63%. The highest worm burden occurred in Troup County, Georgia with 96 parasites per fox, representing 6 species. Lee County Alabama was second with 71 parasites per fox, representing 7 species.

OVERWINTERING IN THREE SPECIES OF PITCHER PLANT MOTH (*EXYRA*: NOCTUIDAE)

Debbie E. Rymal. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

The pitcher plant moth genus, *Exyra* Grt., contains three species, *E. semicrocea* Guen., *E. rolandiana* Grt. and *E. ridingsii* Riley, all obligate inhabitants of pitcher plants of the genus *Sarracenia*. The life history of *E. semicrocea* is being studied in Baldwin County, Alabama. Collections and observations were made of *E. rolandiana* overwintering in New Jersey and of *E. ridingsii* in Georgia. All three species overwinter as larvae but exhibit distinct differences in larval instar, diapause development and nature of the overwintering chamber. Observations were made of the overwintering habits of other pitcher plant associated arthropods in Alabama: the insect families Sarcophagidae, Sciaridae, Sphecidae, and Tortricidae; the mite family Phytoseiidae; and spider families Salticidae and Oxyopidae.

BIVALVE MOLLUSKS OF THE BUTTAHATCHIE RIVER, ALABAMA AND MISSISSIPPI

Paul Yokley, Jr. Dept. of Biology, Univ. of North Ala., Florence, AL 35630.

The Buttahatchie River is a main tributary of the Tombigbee River and is one of the recruitment areas for the many species of freshwater mussels which inhabit the Tombigbee River. No previous survey of the Buttahatchie River mussel fauna has been recorded and few collections have been made from any part of its length. In this study, collections were made along the lower seventy miles of its length from Henson Springs, Alabama to its mouth near Columbus, Mississippi. At least forty different mussel species inhabit this stretch along with the freshwater Asiatic clam, *Corbicula*.

Abstracts

PRELIMINARY OBSERVATIONS ON THE WOOD FROG, *RANA SYLVATICA* (AMPHIBIA: ANURA: RANIDAE) IN ALABAMA

Mark S. Davis. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

The life history and ecology of the wood frog, *Rana sylvatica*, are currently being studied in Alabama. Wood frogs have been found only in the Blue Ridge and upper Piedmont physiographic provinces in east-central Alabama and are restricted largely to mesic hardwood bottomlands. It is not known whether the Alabama wood frog populations are disjunct to or continuous with those in northern Georgia. Breeding activity is of short duration, occurring from late February to early March in semi-permanent woodland pools or ponds. Eggs are laid as submerged, globular masses attached to vegetation. Diameters of eggs and jelly envelopes are larger than those reported from northern populations, with fewer eggs per mass. Tadpoles begin hatching approximately 7 days after egg deposition. Duration of the larval period in the laboratory was approximately 62 days. Leeches, caddisfly larvae, mayfly larvae and salamander larvae were observed feeding on the egg masses and newly hatched tadpoles.

FOOD HABITS OF THE PIG FROG, *RANA GRILIO*, IN SOUTH GEORGIA

Trip Lamb. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

The life history of the pig frog, *Rana grilio*, is currently being studied in South Georgia. A consecutive twelve month food-habit study is still under investigation to determine prey selectivity as well as changes in food habits seasonally and also ontogenetically. A comparison between terrestrial organisms ingested and aquatic organisms ingested shows that aquatic organisms constitute a greater portion of the diet. Males call from March to August and occupy deeper water; females and juveniles occupy shallow water near the shoreline. The various preferred habitats of males and females appears to contribute to dietary differences between the sexes. Pig frogs appear to be opportunistic in their feeding habits. Variation in diets is strongly influenced by habitat selectivity and seasonal variation which determines the availability of different prey organisms.

THE EFFECT OF A CYTOKININ ON FLOWER AND POD ABSCISSION OF SOYBEANS, *GLYCINE MAX* (L.) MERR.

Curt M. Peterson and Michael W. Folsom. Dept. of Botany & Microbiology, Agri. Exp. Station, Auburn Univ., Auburn, AL 36830.

In a field study completed summer, 1978, 77% of the potential pods abscised during development from terminal racemes of 'Bragg' soybeans [*Glycine max* (L.) Merr.]. Most abscissions occurred at distal positions on racemes. Removal of flowers from the first six proximal positions of terminal racemes significantly increased the number of pods retained at

Abstracts

the remaining distal positions on the racemes. However, these additional pods did not entirely compensate for the loss of previously excised proximal flowers, because a significant decrease in total mature pods and seeds was observed when compared to intact racemes. The effects of a foliar spray of the cytokinin, 6-benzyladenine (BA), alone and in combination with the auxin, naphthalene acetic acid (NAA), on the abscission of flowers and pods of terminal racemes were determined. A significant increase in mature pods and seeds was observed only on terminal racemes treated with $10^{-3}M$ BA. This BA treatment significantly reduced the abscission of developing pods within 33 days after treatment was initiated. No significant decrease in seed weight was observed to accompany the increased number of seeds formed by the BA treatment. Changes in distal shoot morphology also were observed on some plants suggesting that at this concentration BA may specifically alter reproductive development to favor increased pod and seed set in soybeans.

YOLK PROTEIN SYNTHESIS IN OVARIECTOMIZED HOUSE CRICKETS

James T. Bradley. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

Four female-specific yolk proteins can be identified in the hemolymph of adult house cricket, *Acheta domestica*, using SDS-polyacrylamide gel electrophoresis. Neither the initial rate of accumulation nor the time of appearance of these proteins following adult ecdysis is affected by ovariectomy performed 6-8 days prior to adult ecdysis. However, by day 10 of adult life, a point midway through the reproductive cycle when the ovaries of control animals are active in yolk deposition and ovulation, the rate of release of newly synthesized yolk proteins from the fat body is greatly depressed in ovariectomized animals. This phenomenon has been demonstrated both *in vivo* and *in vitro*, the latter by incubating fat body tissue from 10-day old sham operated control or ovariectomized animals with 3H -leucine followed by co-electrophoresis of the medium with unlabeled yolk protein and determining the cpm per band per milligram of fat body cultured. Although a negative feedback mechanism for the observed phenomenon has not been ruled out, possible endocrine involvement has been investigated by treating ovariectomized animals with $C^{18}H$ or β -ecdysone and assessing the effects of these treatments upon fat body activity as well as upon the histological state of the neurosecretory cells of the pars intercerebralis.

METHOD FOR DETERMINING PLANKTON TRANSPORT DOWNSTREAM THROUGH MULTIPURPOSE FLOW-THROUGH RESERVOIRS

Donald L. Dycus. Div. of Water Resources, TVA, Muscle Shoals, AL 35660.
Arthur R. Koch. Dept. of Biology, Univ. of N. Ala., Florence, AL 35630.

Plankton transport through Wheeler Reservoir was quantitatively estimated by coordinating biological sampling for phytopigments, organic content, suspended solids, and zooplankton biomass with hydrological investigations, including dye studies, studies of drogue movement at various depths, and velocity studies. All field investigations were

Abstracts

conducted under controlled reservoir flows. A water mass was sampled for biological parameters at two transects; sampling of the water mass at the two locations was assured by following the movement of the water downstream with subsurface drogues. Hydrologic and biological data were related to reservoir cross-sectional areas to estimate the quantity of reservoir plankton and the pattern of movement downstream. The transport rate of zooplankton biomass past the study transects ranged from 37 to 298 kg/h.

YOLK PROTEINS IN DEVELOPING OOCYTES OF *ACHETA DOMESTICUS*

Mary-Lou Nicolaro and James T. Bradley. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

The occurrence of the two major yolk proteins in various stages of developing oocytes of the house cricket, *Acheta domesticus*, were studied electrophoretically. Vitellogenic oocytes were staged using an ocular micrometer, the size classes ranging from $<0.75\text{mm}$ (Stage I) to $>2.0\text{mm}$ (Stage IV) for the mature egg. Stage IV oocytes were divided into thirds and the yolk proteins in each third analyzed to determine if the pattern of distribution of each yolk protein established prior to fertilization is uniform throughout the egg. The yolk proteins obtained were studied quantitatively for the purpose of defining their potential significance in early morphogenetic events. The molecular weights of the yolk proteins were estimated using Non-SDS polyacrylamide disc gels of varying percents acrylamide (Hedrick and Smith 1968). This information was valuable in determining the molar ratios of each protein in oocytes at various stages of development. Finally, two dimensional electrophoresis was performed in order to determine the subunit composition of the two native yolk proteins.

DAILY RHYTHM IN THE OVARIAN RESPONSES TO ovine LH IN GULF KILLIFISH (*Fundulus grandis*)

Mary C. Reddington and Robert MacGregor III. Dept. of Biology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Female *Fundulus grandis* were maintained in aquaria at 22°C (salinity-5ppt) during a 14 hr. daily photoperiod in February and July. Both groups of fish were injected daily for 6 days with either ovine LH (2 μg /g body wt.) or saline (0.04ml) at one of two times during the day: 3 hrs. (Early) or 9 hrs. (Late) after the onset of the photoperiod. Gonadosomatic index and plasma estrogens were determined for each group. The pattern of response to LH injections was similar for fish treated in February or July. Both ovarian growth and increased plasma estrogens were stimulated in those fish injected with LH late during the daily photoperiod, while LH injections early in the day did not significantly stimulate ovarian activity. A daily rhythm of ovarian response to gonadotropin injections have been reported for other teleosts (deVlaming & Vodcnik, 1977). Daily rhythms in circulating gonadotropins also have been identified in several teleost (Peter & Hontela, 1978). The increased responsiveness to LH late in the day is possibly indicative of

Abstracts

low levels of circulating gonadotropin during this time of the day. The identification of such daily rhythms of responsiveness are important with respect to the effectiveness of administered drugs and hormones.

A COMPARISON OF THE ANNUAL CYCLE OF REPRODUCTION IN *FUNDULUS GRANDIS* COLLECTED FROM A NATURAL ESTUARY AND BRACKISH WATER PONDS

R. MacGregor and M. S. Greeley. Dept. of Biology, Univ. of Ala. in Birmingham, Birmingham, AL 35294. W. C. Trimble and W. M. Tatum. Marine Resources Div., Ala. Dept. of Conservation and Natural Resources, Gulf Shores, AL 36542.

The general pattern of the reproductive cycle was similar for the two populations. Both groups began spawning in March-April and ceased activity by late October. However, distinctive differences were evident. The rapid decline in the gonadosomatic (GSI) of males in the wild population did not occur in the cultured fish between June and October. Among the females, the wild populations exhibited a rapid decline in GSI in May whereas the cultured fish maintained large ripe ovaries. By August and October the GSI for females was very similar for the two populations. Plasma androgens for male fish in the culture ponds were six fold greater than from the wild population in March. Androgen levels were more similar and lower by August. Plasma estrogens for both populations paralleled the changes in female GSI, although, values from the cultured fish were significantly greater than from the wild. This information indicates that the culturing of these coastal minnows may have greatly potentiated their capacity to produce offspring by: 1) prolonging maximal gonadal capacity and 2) increasing circulating levels of sex steroids which stimulate spawning activity.

NESTING HABITS OF THE ALABAMA RED-BELLIED TURTLE, *PSEUDEMYIS ALABAMENSIS*

David B. Meany. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

Nine nests of the Alabama red-bellied turtle, *Pseudemys alabamensis*, were discovered on Gravine Island in Baldwin County, Alabama between May 27 and July 15, 1978. The open sparsely vegetated sand beach at the north end of the island comprised the nesting location. Nests were found at varied distances from the water in the fine moist sand at the base of vegetation. Clutch sizes ranged from 3 to 6 eggs buried to depths of 8 to 16 cm. One hundred percent egg mortality resulted from predation by fish crows (*Corvus ossifragus*). Artificially incubated eggs hatched in an average of 63 days at 27.5°C. Hatchlings showed varied plastral patterns along with the characteristic red-orange colored belly. This is the first record of nesting habits and/or hatchling data for *P. alabamensis*.

Abstracts

MORTALITY FACTORS INFLUENCING PUPAL POPULATIONS OF *MALACOSOMA DISSTRIA* IN ALABAMA

Elizabeth J. Stark and James D. Harper. Dept. of Zoology-Entomology, Agri. Exp. Station, Auburn Univ., Auburn, AL 36830.

A survey of mortality factors in pupae of the forest tent caterpillar, *Malacosoma disstria* (Hbn.), in southwestern Alabama was made over a two-year period. Pupae of *M. disstria* were collected from the understory of a cypress-tupelo forest in a deltoid swamp near Bay Minette, Alabama. The pupae were held in individual containers in the laboratory and observed for signs of mortality. Of the various factors noted, which included predation, parasitism, and disease, parasitism was of greatest importance in each of the two years. More than eleven different species of parasites or hyperparasites were isolated and identified. In 1977, the parasite of greatest importance was *Hyphantrophaga hyphantriae* (Tns.), a tachinid fly. In 1978, other muscoid dipteran parasites were present in the highest numbers while incidence of *H. hyphantriae* was extremely low. Other parasites identified in the two-year period were the dipteran, *Sarcophaga houghi* Aldrich, a braconid, *Meteorus* sp., and the ichneumonids, *Coccygomimus maurus* (Cr.), *Itoplectis conquistator* (Say), and *Theronia atalantae* (Cr.). Hyperparasites associated with *Malacosoma disstria* were the braconids, *Aphaereta* sp. and *Synaldis* sp., and the chalcidoids, *Perilampus hyalinus* (Say) and *Brachymeria ovata* (Say).

THE RIFFLE BEETLES (COLEOPTERA: ELMIDAE) OF ALABAMA

Ferrin W. Eiland, II. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

A survey of the riffle beetle fauna of the State of Alabama was conducted from the Spring of 1976 through the Fall of 1978. Twenty-seven species representing nine genera are here reported, including two new species known presently only from Alabama. Notes on the distributions and habitat preferences of Alabama elmids are also presented.

TESTICULAR CYCLE AND SPERMATHECAL ANATOMY OF THE DWARF SALAMANDER, *MANCULUS QUADRIDIGITATUS*

Stanley E. Trauth. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

The seasonal variation in the testes and spermathecal anatomy of the plethodontid *Manculus quadridigitatus* in Alabama was studied by light microscopy. Samples of animals were collected monthly from December 1977 to March 1979. Additional specimens were obtained from the Auburn University Museum collection. Testes begin recrudescence in late March and early April as spermatogonia proliferate. Primary spermatocytes appear in the testicular lobules in June at the caudal end of each testis; a spermatogenic wave advances cephalically during July and August. Testicular size is greatest in September and October when mature spermatozoa fill all lobules. Sperm are abundant in the vas deferens from late

Abstracts

October to mid-February. The cessation of spermiogenesis occurs concomitantly with the advancing caudo-cephalic regression of the testes by late December. The spermatheca is a mass of sperm storage sacs and tubules housed in the dorsal wall of the cloaca of females. A single central collecting tubule, characterized by a highly developed columnar epithelium when sperm are present, connects the tubules of the storage sacs with the cloaca. The storage sacs (16 to 20 in number) are enlarged and highly secretory just prior to spermatophore procurement by females in October and November; these secretions are believed to nourish sperm during their stay in the spermatheca.

EPERYTHROZOON SUIIS INFECTION IN SWINE: A CASE HISTORY

R. M. Creel, Director, Animal Health Dept., Snead State Jun. Col., Boaz, AL 35957.

Eperythrozoon suis infection in swine has been recognized as an ictero-anemia syndrome resembling Anaplasmosis. The disease has been common in the Midwest for a number of years and is now being recognized across Alabama. Clinical signs include the typical anemia and emaciation as well as bizarre reproductive disorders. This paper relates a case history of a herd of 350 breeding animals with reproductive disorders including anestrus and pseudocycysis.

ACUTE EFFECTS OF SEX STEROID HORMONES UPON CARDIAC AND OTHER TISSUES IN ADULT CASTRATED OR OVARIECTOMIZED RATS

Jeffrey L. Schrimsher, P. Samuel Campbell, Michael H. Eley, Harold J. Wilson, and Barbara B. Murray. Dept. of Biology, Univ. of Ala. in Huntsville, Huntsville, AL 35807.

The incidence of cardiovascular disease in premenopausal women is lower than in males. This has been attributed to many factors including sex hormone environment. Since heart has been reported to have putative estrogen receptors, a molecular basis for sexual influences upon cardiac function is evident. Our studies were initiated to explore possible sex steroid influences upon cardiac tissue. Initial studies utilizing adult ovariectomized or castrated adult rats indicate that administration of estradiol benzoate (E₂B) or testosterone propionate (TP) to such animals produces differential effects which do not appear solely hormone dependent in that the genetic sex may interact to affect the response to the particular hormone. The appropriate hormone (*e.g.*, TP injected males) produced the most dramatic effects upon the animal/tissue. More specifically, TP administration produced greater anabolic effects in males than females, while E₂B administration resulted in greater weight loss in females than males. Total soluble protein in heart homogenates was considerably higher (~2X) for females in all treatment groups. However, E₂B treatment resulted in increased total protein in both sexes, although there was a concomitant decrease in male heart tissue mass. Such differences were not observed in kidney control tissue. The appropriate hormone treatment stimulated a Kreb's cycle enzyme in heart mitochondria, while exerting a reciprocal effect upon a glycolytic branchpoint enzyme. The preliminary data suggest that sex hormones stimulate differential carbon utilization.

Abstracts

LARVAL DEVELOPMENT AND MORTALITY IN THE BEET ARMYWORM

Mary U. Ball. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

The effect of crowding on larval development and mortality in beet armyworms reared in 1 oz. cups on artificial diet was evaluated. Mortality rate, mean pupal weight, sex ratio, and pupal yield per cup were determined for larvae reared singly or in groups ranging from 2 to 5 larvae per cup. Significant differences were found for mortality rate and yield but not for mean pupal weight or sex ratio. The importance of interactions between larvae as a factor in increasing mortality rate was evaluated by comparing results for larvae reared 2 per cup but separated by an acetate partition to those for pairs of larvae which could interact freely. This study is of practical importance in developing a rearing strategy based on the supply of eggs and desired yield of pupae which is economical of space and diet medium. The observations may also be useful in identifying factors which influence population growth and dispersal under field conditions.

DIROFILARIA IMMITIS: SEROLOGICAL RESPONSE OF BEAGLES THROUGHOUT THE COURSE OF INFECTION

Peter S. Sakas and William L. Current. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

Helminth free beagles were maintained in strictly controlled environmental conditions and were experimentally infected with *Dirofilaria immitis* by subcutaneous and oral routes of inoculation. Sera from each of the groups were studied by electrophoresis to detect differences in major components. Dogs infected subcutaneously displayed significant increases in the levels of B-globulins and γ -globulins when compared to the control group. Sera was then subjected to single radial immunodiffusion to determine if this increase was due to a rise in antibody levels. Concentrations of canine IgG and IgM were determined and compared with the life cycle of the parasite. The most marked antibody production was at the time of the second molt (3 months post infection) and during the period of initial microfilarial production (6 months post infection). The highest level of antibody in the infected group was during this period of early microfilaremia and serological tests are now in progress to determine antibody specificity.

A SURVEY OF THE HERPETOFAUNA OF THE LIMESINK REGION OF SOUTHEASTERN ALABAMA

Thomas R. Jones. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

The Alabama limesink region covers large portions of Houston, Geneva and Covington counties in southeastern Alabama. Sinkhole ponds were formed from extensive solution and slumping of Eocene to Oligocene limestones primarily belonging to the Moody's Branch Formation and the Ocala

Abstracts

Limestone. Shallow ponds, some of which may be semipermanent in duration, are common in Houston and Geneva counties. These ponds are usually covered with a heavy growth of waterlilies and have substantial stands of cypress. Field studies were conducted during the summer and fall of 1978 to determine the herpetofaunal composition of these ponds. An attempt was made to document the presence of certain Lower Coastal Plain species in Geneva and Houston counties that are known to inhabit sinkhole ponds in Covington County. New county records were established for *Ambystoma cingulatum*, *Siren intermedia*, *S. lacertina*, *Pseudemys floridana*, and *Trionyx ferox*. Typical wetland associates included *Hyla cinerea*, *Rana gryllo*, *R. utricularia*, and *Natrix fasciata*. Evidence for the presence of *Alligator mississippiensis* was found in Houston and Geneva counties. The most common inhabitant of the semipermanent ponds was *Manculus quadridigitatus*.

EFFECT OF TEMPERATURE ON DEVELOPMENT OF *GLOMERELLA* LEAF SPOT OF APPLE

Joni M. Snell and A. J. Latham. Dept. of Botany and Microbiology, Auburn Univ., Auburn, AL 36830.

A strain of *Glomerella cingulata* (Ston.) Spauld. and Schrenk, morphologically similar to the apple bitter rot fungus, causes a leaf spot on Golden Delicious apple trees. The effects of temperature on lesion development was studied at 4-degree intervals from 16 to 32 C on apples using 3-potted 'Golden Delicious' plants per temperature and replicated 3 times. Plants were inoculated with a suspension averaging 8,000 spores per ml, covered with a plastic bag, and incubated for 7 days. The average lesion diameter on leaves incubated at 16, 20, 24, 28, and 32 C were 3.9, 4.9, 9.5, 10.7 and 6.9 mm, respectively. Lesions occurred within 72-hr incubation at the optimal temperature of 28 C. Leaf spots developed on juvenile, i.e., unfolding, leaves and on intermediate-aged leaves. Older or senescing leaves developed a yellow mottle.

INHIBITORY EFFECTS OF SELENIUM ON INDUCED RAT OVARIAN TUMORS

C. Duane Randleman. Dept. of Biology, Samford Univ., Birmingham, AL 35209.

The objective of this research was to study the effects of selenium on the growth of ovarian tumors induced by a surgical process in albino SAF/SD *Rattus norvegicus*. Surgery was performed on 38 female rats. Nine were used as controls and the remaining 29 experimental rats were given diets supplemented with selenium. The induction of ovarian tumors in all 38 rats was obtained through an ovary to spleen transfer. Under normal conditions solid tumors of the ovary develop within 4-10 weeks and histopathological studies indicate the tumor is an adenocarcinoma. After surgery, drinking water containing 1 ppm selenium (sodium selenite, Na₂SeO₃) was given to the 29 experimental rats for the duration of

Abstracts

the study. After 8 weeks, 66.6% (6/9) of the control rats had developed solid tumors whereas only 6.8% (2/29) of the rats with the selenium supplement developed tumors. These tumors were considerably smaller than the neoplasms in the control. These results indicate that selenium appears to inhibit or prevent the growth of surgically induced ovarian tumors in rats. The author wishes to thank Dr. Ellen McLaughlin and Dr. George F. Scofield for their valuable assistance in this project.

THE FISHES OF CYPRESS CREEK, WAYNE COUNTY, TENNESSEE, LAUDERDALE COUNTY, ALABAMA

Charles Gooch. Water Quality and Ecology Branch, TVA, Muscle Shoals, AL 35660.

Eighty-two species of fish have been recorded from the Cypress Creek watershed. Sixty-nine of these species still inhabit the drainage as indicated by recent collections. A total of 4,645 fish were collected by the author. There were 710 *Clinostomus funduloides* Girard collected, comprising 15.3 percent of the total number of fish collected. *Campostoma anomalum* (Rafinesque) accounted for 686 of the specimens collected or 10.5 percent of the total. As the two most abundant fish species collected, *Clinostomus funduloides* and *Campostoma anomalum* may represent those species having the greatest populations in the drainage. Discrete habits have made some species difficult to capture; thus, their actual density is unknown. Darters of the genus *Etheostoma*, represented by twelve species, comprise the largest taxonomic group in the drainage. Nine species of the genus *Notropis* have been recorded in recent collections, making this the second largest taxonomic group. Distributions of the numbers of species within the drainage area, as determined by the author's collections, are Cypress Creek including Threet Creek--43 species; Little Cypress Creek including Chisholm Branch--42 species; Middle Cypress Creek including Greenbriar Branch--36 species; Lindsey Creek--20 species; Cox's Creek--13 species; and Burcham Creek--14 species.

CHEMISTRY

ANALYSIS OF ABSORPTION AND BOUND-FREE FLUORESCENCE IN CESIUM DIMER

M. B. Moeller. Dept. of Chemistry, Univ. of N. Ala., Florence, AL 35630. Joel Tellinghuisen. Dept. of Chemistry, Vanderbilt Univ., Nashville, TN 37235.

The absorption spectrum of Cs_2 shows several strong band systems. The system with a peak absorption near 4800\AA is particularly complex and has defied a conventional analysis. Laser excitation of Cs_2 vapor in the blue-green produces a fluorescence spectrum which is partly discrete and partly diffuse. The fluorescence terminates in a series of

Abstracts

diffuse bands near 6100\AA . Using an RKR derived lower state potential we have been able to deduce approximately potential curves for the upper states involved in the blue-green absorption and the diffuse fluorescence. This was done by trial-and-error spectral simulation to the experimental spectra. The experimental features are best fit by postulating two excited states. The upper state in the absorption we have tentatively called the E state. The potential function for this state, U_E , has $R_E = 5.1\text{\AA}$, $\omega_E = 32.7\text{ cm}^{-1}$, $T_E = 20430\text{ cm}^{-1}$, and $D_E = 5291\text{ cm}^{-1}$. The upper state for the fluorescence bands near 6100\AA has $R_E = 7.75\text{\AA}$, $\omega_E = 12.6\text{ cm}^{-1}$, $T_E = 19410\text{ cm}^{-1}$, and $D_E = 5550\text{ cm}^{-1}$.

DEVELOPMENT OF BETA SPECTROSCOPY FOR 89-90 STRONTIUM

J. T. Harvey. TVA, River Oaks Bldg., Muscle Shoals, AL 35660.

The Nuclear Regulatory Commission (NRC) requires environmental monitoring for, among others, 89 and 90 strontium. This requirement is currently satisfied by doing a chemical separation for strontium and the subsequent counting of the precipitated strontium on a beta counting system such as the Beckman Wide Beta. This paper will present results from an investigation into the development of a beta surface barrier detector and uses a standard multichannel analyzer. Experimental data will be presented along with the possible methods of data reduction such as Fermi-Kurie plots or use of a computer code such as ALPHA-M. Cost analysis of a beta spectroscopy system versus a beta counting system will also be presented.

DETERMINATION OF STABLE IODINE IN MILK

James W. Dillard and Billy B. Hobbs. TVA, River Oaks Bldg., Muscle Shoals, AL 35660.

The radiochemical analysis of iodine-131 in cow's milk involves the addition of stable iodine carrier with ultimate determination of the recovered carrier yield. For the most accurate measurements, the yield determinations must be corrected for the naturally occurring stable iodine in milk. The stable or unbound iodine in cow's milk has been found to be present as iodide. Specific ion electrode determination of the unbound iodide utilizing the method of Gran's plot is discussed. The advantages of the Gran's plot method over a simple calibration plot or one point standard addition are evaluated. The results for stable iodine corrected and uncorrected environmental milk samples are compared.

DETERMINATION OF 210-LEAD AND 210-POLONIUM IN THE ENVIRONMENT

William L. Raines, James W. Dillard, and Larry G. Kanipe. TVA, River Oaks Bldg., Muscle Shoals, AL 35660.

The isotopes 210-polonium and 210-lead are products of the natural decay series of 238-uranium. They are key isotopes in environmental monitoring programs for regions where uranium is mined or processed.

Abstracts

A method for determination of these isotopes in environmental samples is discussed. Lead carrier is added and subsequent formation of several lead compounds is the basis for separation and purification. The 210-polonium activity is determined by alpha spectroscopy after polonium is plated on a nickel disk. The 210-lead activity is determined from the activity of the daughter 210-polonium after a 30-day ingrowth period. A tracer of 208-polonium is used to determine the efficiency of the plating and counting process. Lead chemical yields are determined by anodic stripping voltammetry.

URANIUM AND 226-RADIUM BY GAMMA-RAY SPECTROSCOPY

L. G. Kanipe, R. P. Powers, and B. B. Hobbs. TVA, River Oaks Bldg., Muscle Shoals, AL 35660.

The analyses of uranium and radium-226 have traditionally been performed by wet chemical separations requiring large expenditures of time and reagents. Since these analyses are essential to environmental monitoring programs for uranium mining and milling operations, a gamma-ray spectroscopy technique has been developed. This technique also has important applications to sample types which present difficult chemical problems such as phosphate ore, fly ash, and coal, in achieving quantitative measurements. The technique is based upon determining radium-226 through its daughter radionuclides after secular equilibrium has been established. The radium-226 contribution to the low-energy uranium peak at 186 KeV is removed to allow estimation of the uranium content. The technique is sensitive and cost effective while avoiding the problems of sample homogeneity normally associated with environmental samples.

STUDIES ON THE COPPER COMPLEX OF PHEOPHYTIN

Karen M. Moore and Gerald S. Vige. Dept. of Chemistry, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

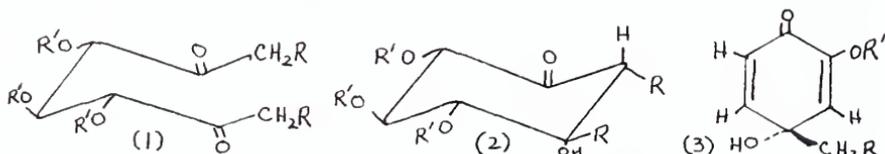
Interest in the polyphenol oxidation mechanism of copper enzymes has lead to the investigation of the copper complex of pheophytin as a model system for the study of copper catalyzed polyphenol oxidations. The copper complex was prepared by removing the magnesium ions from commercially prepared chlorophyll and inserting Cu(II) ions in the porphyrin-type structure of the resulting pheophytin. It has been characterized by elemental analysis and its i.r. spectra in both solid and solution. The u.v. spectrum has been studied and molar absorptivities determined. The magnetic susceptibility has been measured by n.m.r. The polyphenol oxidase activity of this complex toward five different o-diphenols has been determined by monitoring the oxidation reaction spectrophotometrically. These results will be presented.

Abstracts

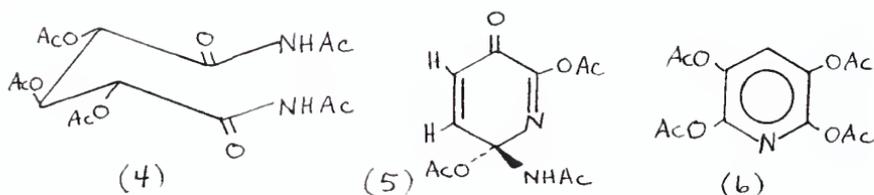
NITROGEN HETEROCYCLES FROM SUGAR ACID DIAMIDES

Kathy Semk and Donald E. Kiely. Dept. of Chemistry, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Earlier studies in this laboratory have shown that δ -dicarbonyl sugar derivatives (1) cyclize by intramolecular aldol condensations to the cyclohexanone compounds (2), while increased reaction times lead to the substituted cyclohexadienones (3).



Our more recent studies have shown an analogous situation in which substituted sugar acid diamides (4) are converted in a similar manner to nitrogen heterocycles (5) and (6).



CHEMISTRY AT OLD LA GRANGE, ALABAMA'S FIRST COLLEGE

Richard C. Sheridan. 105 Terrace Street, Sheffield, AL 35660.

Alabama's first college was established by the Methodist Church in January 1830 at the village of La Grange in Franklin County (now in Colbert County). Science courses were taught at La Grange College from the beginning, and the Chair of Chemistry was created in 1833. The professors who occupied this Chair were Dr. William H. Harrington, Dr. Thomas Barbour, Henry Tutwiler, James W. Hardy, Thomas P. Hatch, and Rev. William G. Williams. Brief biographies are presented on each professor, and some of their experiments and apparatus are described. The college closed in 1862 due to the Civil War, and the buildings were burned by Federal troops in 1863.

FACULTY RESEARCH AT A SMALL COLLEGE OR UNIVERSITY?

Raymond E. Isbell. Dept. of Chemistry, Univ. of N. Ala., Florence, AL 35630.

Struggles are a way of life for most chemistry departments at small colleges and universities. Some of these are budget, number and quality

Abstracts

of faculty, faculty loads, credit hour production, enrollment, number of majors, etc. Perhaps the biggest struggle and the one most often lost is the struggle of faculty members to stay alive scientifically by research. This paper will deal with the need for faculty research, problems faced by researchers, and some possible solutions to the problems.

GASOHOL FROM NEWSPAPERS: A SURVEY

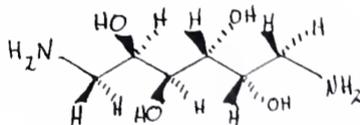
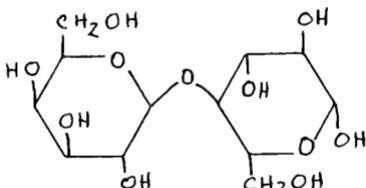
Charles W. Richmond and Raymond E. Isbell. Dept. of Chemistry, Univ. of N. Ala., Florence, AL 35630.

The chronic nature of the energy crisis has indicated that the solution to the crisis will not be a single alternate form of energy but will probably be a combination of conservation and several different contributory processes. Use of gasohol, a blend of gasoline and ethyl alcohol, has been proposed as one contributory process. The feasibility of gasohol increases as the price of gasoline increases and/or the price of alcohol decreases. One attractive route to ethyl alcohol involves the acid hydrolysis of cellulosic materials to sugars and the fermentation of the sugars to alcohol. We have surveyed the literature pertaining to these processes and plan to study the conversion of waste newspapers to alcohol. This project is supported by the Tennessee Valley Authority and the Northwest Alabama Council of Local Government.

SYNTHESIS OF A 1,6-DIAMINOALDITOL USING TBDMS ETHERS

Juan L. Navia and Donald E. Kiely. Dept. of Chemistry, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

We are reporting on the use of the *t*-butyldimethylsilyl (TBDMS) ether as a hydroxyl group protecting agent in the preparation of 1,6-diamino-1,6-dideoxygalactitol (2) from lactose (1). This protecting group is relatively new in its application to carbohydrate synthesis and offers certain advantages over some of the more traditional protecting groups. These will be discussed. The synthetic scheme was initiated with nitric acid oxidation of 1 to galactaric acid. The acid is converted to dimethyl galactarate with methanolic HCl. Silylation of the diester yielded methyl 2,3,4,5-tris (*t*-butyldimethylsilyl) galactarate-1,4-lactone. The structures of these compounds were deduced by GC/MS and other spectroscopic methods. Ammonolysis of the ester-lactone yielded three diamides due to rearrangements of the TBDMS groups. The structures of these compounds were elucidated principally by NMR and IR. Finally, the diamids were reduced with diborane to (2). This method appears to be adaptable to the preparation of other 1,6-diaminoalditols from aldoses.



Abstracts

GLC DETERMINATION OF PHENACEMIDE IN TABLETS

Paul Connolly, Susan Sirmans, Albert A. Belmonte, and Charles M. Darling. School of Pharmacy, Auburn Univ., Auburn, AL 36830.

Phenacemide is a commercially available anticonvulsant in tablet form. The official assay for the determination of phenacemide in National Formulary (N.F.) tablets requires much handling, transfer and time. A procedure using a Gas Liquid Chromatograph (GLC) was developed and was shown to be as accurate as the N.F. method as well as less time-consuming. The procedure involves injecting an aliquot of phenacemide extracted from the tablets, an internal standard, pentylenetetrazole, and isopropyl alcohol into the GLC and recording the resulting peaks. The phenacemide was extracted by refluxing in isopropyl alcohol for one hour. The solution was filtered, the internal standard added, and a 3 μ l aliquot was then injected. The amount recovered was determined by substituting the areas under the resulting curves into an equation derived from a standard curve determination. Comparison of the percent recovery of phenacemide using the N.F. and the GLC methods show no statistical difference between the two techniques.

MINDO/3 CALCULATIONS ON ISOMERS OF N-METHYL ACETAMIDE

Barbara L. Hoesterey, W. C. Neely, and S. D. Worley. Dept. of Chemistry, Auburn Univ., Auburn, AL 36830.

MINDO/3 calculations were performed on five isomers of the formula C_3H_7NO , including two isomers of N-methyl acetamide, an imino acid, an enamine, and an imidate. The calculated heats of formation were used to determine room temperature equilibrium constants for interconversion between the isomers, assuming a negligible entropy effect.

$$\Delta G = \Delta H_f = -RT \ln K$$

These results are important in view of the controversy concerning tautomerism of the amide group.

A COMPARATIVE STUDY ON INDUCTION OF MIXED FUNCTION OXIDASE ACTIVITY IN THE RAT, MULLET, AND KILLYFISH

Melvin V. Kilgore, David L. Elam, and Paul Melius. Dept. of Chemistry, Auburn Univ., Auburn, AL 36830.

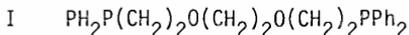
The inducibility of mixed function oxidase activity in the rat (*Rattus norvegicus*), mullet (*Mugil cephalus*), and killyfish (*Fundulus grandis*) has been evaluated with the *Salmonella*/microsome test, SDS-gel electrophoresis and enzyme assays such as NADH-cytochrome b₅ reductase activity and NADPH-cytochrome P-450 reductase activity. Preliminary data indicates that inducible pathways are present in all test organisms, however, mixed function oxidase activity is lower in the fish species as compared to those found in the rat. (Support for this project has been received from the Environmental Protection Agency.)

Abstracts

NICKEL II COMPLEXES OF THE LIGAND ETHYLENE BIS(OXYETHYLENE)BIS(DIPHENYLPHOSPHINE)

J. G. Taylor and W. E. Hill. Dept. of Chemistry, Auburn Univ., Auburn, AL 36830.

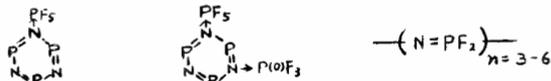
Nickel II complexes of the general form NiX_2L or $NiY_2L(H_2O)_x$ have been prepared ($X = Cl^-, Br^-, I^-,$ or SCN^- and $Y = Cl^-$ or BF_4^- , $x = 1-2$) and characterized by elemental analysis, infrared spectroscopy, electronic spectroscopy, magnetic moment, and conductivity measurements. The electronic reflectance spectra suggest an octahedral geometry in the case of the chloride and bromide (NiX_2L) and a square planar arrangement for the thiocyanate and iodide. In dichloromethane solution geometry changes are observed for the chloride, bromide, and iodide. The chloride, bromide, iodide, and thiocyanate are nonconducting in dichloromethane solution. The magnetic moment measurements in the solid state are also in agreement with the above assignments. Of the hydrated complexes, the chloride appears to have an octahedral geometry in the solid state--indicated by the electronic reflectance spectrum. The structure of the chloride in dichloromethane solution is the same as the $NiCl_2L$ complex, both having identical solution spectra. The tetrafluoroborate complex is diamagnetic in the solid state. The infrared spectrum and the conductivity measurement indicate an ionic structure.



N-HALOSILAZANES CONTAINING PHOSPHORUS FLUORIDES

S. M. Ho and W. E. Hill. Dept. of Chemistry, Auburn Univ., Auburn, AL 36830.

The reactions of $BrN(SiMe_3)_2$ (I) with phosphorus fluorides have been investigated. The reaction of (I) with PF_5 proceeds with the evolution of trimethylsilyl fluoride and Br_2 to give a series of cyclic and polymeric phosphonitriles. Some of which are shown below:



With $P(O)F_3$, ring products are generally not observed but hydrazines of the type are



produced. Bromine and trimethylsilyl fluoride are also evolved. Phosphorus trifluoride does not react with $BrN(SiMe_3)_2$, a probable consequence of its lower Lewis acidity. Alternate routes to N-halogen containing phosphorus fluorides have also been investigated. These include the reactions of $Me_3SiNHP(X)F_2$ species ($X = O, S$) with C_4H_9Li followed by reaction with Cl_2 and the direct reaction of the silylamine with N-halosuccinimides or t-butyl hypochlorite. The reaction products have been identified by mass spectrometry, ^{19}F , ^{31}P , and 1H nmr spectroscopy and infrared.

PHASE-TRANSFER CATALYSIS OF BENZIMIDAZOLE
AND BENZOTRIAZOLE ALKYLATIONS

Dale Burkett and Lon J. Mathias. Dept. of Chemistry, Auburn Univ., Auburn, AL 36830.

In the course of our investigations of several benzimidazole derivatives and polymers, we required the N-alkylated compounds as intermediates. Previously reported procedures gave low yields, were somewhat tedious to perform, and often resulted in further conversion of the desired mono-alkylated product to the N,N¹-dialkylbenzimidazolium salts. This latter result is due to the greater reactivity of the monoalkyl derivatives toward the alkylating agents than the starting benzimidazole. The most reasonable way to overcome this problem is to alkylate the benzimidazole anion under conditions with which the desired product does not further react. While the alkalai salts of benzimidazole may be methylated in aqueous solutions with dimethylsulfate, similar procedures for higher alkyl groups fail due to insolubility of the alkylating agents in water. The procedure described here is a mild, one-step synthesis employing 18-crown-6 as a phase-transfer catalyst. The method involved stirring a concentrated KOH solution of the benzimidazole (or benzotriazole) anion with a neat or CCl₄ solution of an alkyl halide and a catalytic amount of 18-crown-6. Substituents on the benzimidazole in the 5(6) position include the methyl-, chloro-, and nitro-groups; the isomeric 1,5- and 1,6-n-butyl bromide and p-bromobenzyl bromide.

THE REACTION OF ATOMIC CARBON WITH BENZENE

C. T. Koch, K. A. Biesiada, and P. B. Shevlin. Dept. of Chemistry, Auburn Univ., Auburn, AL 36830.

Atomic carbon, generated in a carbon arc, has been allowed to react with benzene in the condensed phase at -196°. The products of this reaction are toluene, cycloheptatriene, benzocyclopropene, phenylacetylene, phenylcycloheptatriene, and biphenyl. The mechanism of this reaction will be discussed.

NEW DEVELOPMENTS IN THE SURFACE MODIFICATION OF GLASS CAPILLARY COLUMNS

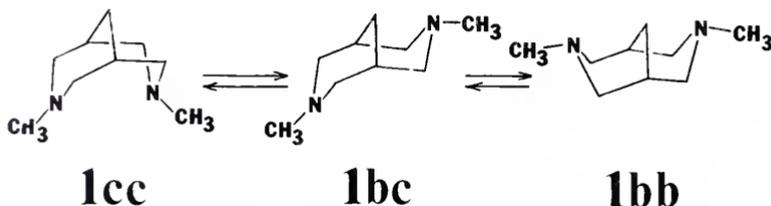
Margaret C. Shoults and Wolfgang Bertsch. Dept. of Chemistry, Univ. of Ala., University, AL 35486.

Glass capillary columns have become increasingly important in the field of environmental analysis because of their high resolution capabilities and the relative inertness of the glass wall. The preparation of an efficient glass capillary column requires that an even coating of stationary phase be applied to a well deactivated surface. Deposition of an even film is sometimes difficult due to the high surface energy of glass. When a phase with high surface energy, such as polar phases, is coated on a glass surface, it will tend to "bead up" on the glass unless some roughness is provided. There are several approaches to the surface modification of the glass wall. These techniques will be described in detail and scanning electron micrographs of the results will be shown.

LONE PAIR-LONE PAIR INTERACTION IN A BICYCLIC DIAMINE. PHOTOELECTRON SPECTROSCOPY AS A TOOL IN GAS PHASE CONFORMATIONAL ANALYSIS

M. Eggers, K. Roberts, P. Livant, and S. D. Worley. Dept. of Chemistry, Auburn Univ., Auburn, AL 36830.

The He(I) photoelectron (PE) spectrum of N,N'-dimethyl-3,7-diazabicyclo[3.3.1]nonane, 1, ("N,N'-dimethylbispidine") reveals a nitrogen lone pair-nitrogen lone pair splitting the magnitude of which suggests that the conformational equilibria shown below lie in favor of the "chair-chair" conformation, 1cc. Molecular orbital calculations (MINDO/3, STO3-G) support this inference. PE spectra of model compounds suggest that the nitrogen-nitrogen splitting in 1 is occurring through space. Supported in part by an Auburn University Intramural Grant-In-Aid.

THE ACTIVE CENTER OF INVERTASE FROM *CANDIDA UTILIS*: KINETIC AND CHEMICAL STUDIES

Jesse Ezzell, William DeVault, and Jonathan Ford. Dept. of Chemistry, Birmingham-Southern Col., Birmingham, AL 35204.

The ionizing functional groups at the active center of *Candida utilis* invertase were determined by kinetic methods using sucrose and raffinose as substrates. Dixon plots of $-\log$ Michaelis constant against pH at 30° for sucrose hydrolysis showed ionizing groups in the free enzyme with apparent pK_a 4.4, and in the enzyme-substrate complex with pK_a 3.8. Similar plots for raffinose at 25° gave pK_a values of 4.3 and 3.5, respectively. Redetermination at 50° of the pK_a in the free enzyme seen in raffinose hydrolysis allowed calculation of the heat of ionization, which was found to be -810 cal/mole. This group was identified as carboxyl. The heat of ionization for both groups in the free enzyme and enzyme-substrate complex seen in sucrose hydrolysis was 8900 cal/mole. It is suggested that this relatively high value could be due to a carboxyl group whose ionization was altered by local protein effects or due to an imidazole group of histidine. Sucrose hydrolysis exhibited substrate inhibition at pH's above 4.5 and, with both sucrose and raffinose as substrates, there was apparent cooperative substrate binding. The enzyme was inhibited by iodoacetamide at several pH's, but not by iodoacetic acid, Koshland's reagents I and II or 5,5'-dithiobis(2-nitrobenzoate). These results suggest that a negatively charged active center carboxyl repels anionic alkylating and disulfide exchange reagents

Abstracts

and also that tryptophanyl indole and methionyl thiomethyl may not participate at the active center. The group reacting with iodoacetamide is currently under study using highly purified enzyme preparations.

DEACTIVATION OF GLASS CAPILLARY COLUMNS

Anita Thompson and Wolfgang Bertsch. Dept. of Chemistry, Univ. of Ala., University, AL 35486.

The use of glass capillary columns in gas chromatography is becoming increasingly important because of the relative inertness of the glass as compared with other types of columns. However, the glass is not completely inert and can react with labile compounds and interfere with separation. Consequently, the deactivation of the glass surface is an important step in preparing glass capillary columns. The surface of the glass contains polar Si-OH groups and trace metal ions which can interact with solutes causing peak broadening, peak tailing or adsorption. There are several methods of deactivation: 1) silylation of the glass using gas phase or liquid phase reagents, 2) modification of the glass surface, 3) bonding a thin film of polar phase to the wall, 4) forming a polymer on the surface of the glass. Only the first method, silylation, will be discussed in detail.

GEOLOGY

PETROLOGY OF THE FARMVILLE GNEISS, NORTHWESTERN LEE COUNTY, ALABAMA

James A. Fouts. Dept. of Geology, Auburn Univ., Auburn, AL 36830.

The Farmville gneiss is one of several bodies of foliated granitic rocks exposed within the Opelika complex of the Alabama Inner Piedmont. In the southeastern part of the Waverly Quadrangle, the Farmville gneiss is exposed in a northeasterly trending linear zone with a maximum outcrop width of approximately 1400 meters. The body is generally concordant with the surrounding schists but three small bodies are exposed south of the main belt suggesting that it is locally discordant. The gneiss consists of microcline, quartz and oligoclase (An₂₆) with variable amounts of biotite and muscovite. The foliation is defined by the concentration of biotite in thin bands and is most distinct in areas where biotite is most abundant. The foliation is generally parallel to the schistosity in the surrounding units. The typical gneiss is medium-grained but porphyroblastic varieties occur locally. Chemically the rock is composed mostly of SiO₂ (74-76 percent), Al₂O₃ (12-14 percent), Na₂O (3-4 percent) and K₂O (5-6 percent). The outcrop pattern, mineralogy and chemistry all suggest an igneous origin for the body. The well developed foliation indicates that the body was emplaced before or during the last period of regional metamorphism.

FOUNDATION PROBLEMS IN SOILS DERIVED FROM CARBONATE ROCKS*

Lawrence J. Rheams. Geological Survey of Ala., University, AL 35486.

Soils derived from the weathering of carbonate rocks can produce special foundation problems for even the small single family dwelling. Although people are becoming more and more aware of problems related to surface subsidence produced by solution cavities, a more subtle problem related to the shrink-swell potential of residual soils needs to be better understood. Observations in areas of Jefferson County, Alabama, that are underlain by carbonate rocks indicate information concerning clay soils is needed for proper foundation design. In most areas, soil studies for residential construction are limited to percolation tests as needed for septic tank installations. In such an area of Jefferson County, cracks were observed in the brick veneer of two small dwellings. These cracks formed after several months of extremely dry weather. Drilling failed to find any sinkholes in the area, and the soil around the houses displayed desiccation cracks. Also, similar desiccation cracks in soils were observed during the same period in other areas of Jefferson County underlain by carbonate rocks.

* Approved for publication by the State Geologist.

GEOLOGY AND GEOCHEMISTRY OF THE STONE HILL MASSIVE SULFIDE COPPER DEPOSIT: CLEBURNE AND RANDOLPH COUNTIES, ALABAMA

Dave Whittington. Dept. of Geology and Geography, Univ. of Ala., University of AL 35486.

The Stone Hill Massive Sulfide Copper Deposit is located in the high rank metamorphics of the Northern Piedmont of Alabama. The deposit consists of a unit of stringer ore 20 to 30 feet in thickness which is bounded above by a zone of massive ore 3 to 5 feet thick while a similar layer bounds the bottom of the stringer ore zone. The deposit occurs concordantly within a thin unit of quartz-sericite schist which in turn is concordantly enclosed within an extensive amphibolite. Linear relations between MgO and Ni, Cr, V, and FeO/MgO indicate the amphibolite is of igneous origin (rather than sedimentary). The average major elemental analysis indicates a composition similar to low-K basalt. Sulfide phases in the ore include pyrite, pyrrhotite, chalcopyrite, and sphalerite. Polished sections show a strong affinity of chalcopyrite for sphalerite. Zonation of base metals through the ore zone (e.g. Zn increase in massive ore, Cu increase in stringer ore) have not been established for the cores sampled. Four working hypotheses have been considered as a basis for further investigation of the deposit's relation to the country rock; perhaps the "sandwich" occurrence of stringer ore between massive ore zones is a primary stratigraphic feature resulting from two mineralizing episodes, perhaps it is due to D-1 folding of a single deposit, perhaps it is a sequence repeated by stacking of a single deposit by a minor thrust fault, and perhaps it is due to some combination of the first three. These hypotheses are not binding or exclusive, they have simply been adopted as possibilities for the

Abstracts

purpose of further critical investigation. Classifying the deposit (Hutchinson, 1973) at this time is premature.

DESCRIPTION OF A FLOOD DELTA THANATOCOENOSE, EUTAW FORMATION, MONTGOMERY COUNTY, ALABAMA

Wallace A. McCord. Dept. of Geology, Auburn Univ., Auburn, AL 36830.

The Tombigbee Sand (Ke) is a member of a belt of Late Mesozoic rocks which crops out in the northern Gulf Coastal Plain in Alabama. The Tombigbee Sand is a marine unit consisting of a fine to medium sand, well-sorted, and cross-laminated. The area of study includes outcrops of the Tombigbee Sand as exposed at the Industrial Terminal, Montgomery, Alabama. This exposure consists of a basal, bioturbated argillaceous sand, a middle unit of large-scale cross-bedded sandstone and a top unit of bioturbated sand interbedded with a variably inundated rock of *Orphiomorpha* burrows and overlain by a well-lithified sandstone caprock. A belt of ledge-forming *Ostrea cretacea* reef rock trends east of this locale from Macon County to Muscogee County, Georgia. The environment of deposition has been inferred by R. S. Taylor (personal communication) to be a sound or lagoon protected from the open sea by a string of barrier islands. The oysters are not observed *in situ* west of Montgomery County. W. Sitz (1974) and B. Coons (1977) investigated the paleoenvironment of the Eutaw at this locale, and have interpreted the massive cross-beds to be an off-shore bar or tidal shoal environment. A paleontological study of the area yielded several pelecypods, burrows, echinoid plates and phosphatic particles which included several varieties of shark's teeth, vertebrae and dermal plates, pelecypod casts, and fragments of crustacean carapaces. The transported fauna constitutes a tidal delta thanatocoenose.

SOME CHEMICAL VARIATIONS WITH RANK FOR CERTAIN ALABAMA COALS

Reynold Q. Shotts. Dept. of Mineral Engg., Univ. of Ala., University, AL 35486.

Not all coal is useful for metallurgical purposes. Some Alabama coals are of metallurgical grade and some are not. The object of this study was to determine, from coal analyses or other data, the distinguishing compositional or physical property differences and to estimate the quantity and quality of known resources of coals most suitable for metallurgical or steam purposes. Statistical studies of almost 1300 published coal analyses revealed that the percents of fixed carbon, total carbon, and oxygen could be used to distinguish metallurgical from other coals, when calculated to the unit coal (dry, mineral matter-free) basis. Unit heating value and the ratio of the number of unit carbon atoms to unit hydrogen atoms were also useful to a lesser extent. As an example, for the Mary Lee group of coalbeds, known coking coals have total carbon 87-89.4%; 66.5-74% fixed carbon, under 6% oxygen. "Borderline" Mary Lee coking coal ran: carbon 85-87%, fixed carbon 65-66.5%, and oxygen 6-8%. Where analyses of deep coal are unknown, Hilt's Law and David White's

Abstracts

dynamical and regional metamorphism theories should permit a first order estimate of rank until better data are available.

CHANGES IN ENVIRONMENTAL PARAMETERS AS SHOWN BY SOME SOLITARY CORALS

Laura A. Waters. Dept. of Geology, Auburn Univ., Auburn, AL 36830.

The prominent growth rings occurring regularly on coral epithecae are presumed to represent daily increments of growth. Groups of daily increments are marked off by circular constrictions. These constrictions are thought to define monthly intervals. The daily and monthly growth structures are believed to result from diurnal fluctuations in the coral polyp's metabolism. A count of the number of daily increments contained between two successive monthly bands indicates the number of days per month for the geological period during which the coral lived. Daily growth rings were counted on corals of Silurian, Devonian, Mississippian, and Pleistocene Ages. Each assemblage from each period was collected from a single locality. The average number of days in a month was determined for these periods averaging groups of consecutive band counts rather than averaging all the counts on a particular coral. This procedure is used because it minimizes the effect of slight variations in the normal periodic development of the growth rings. This research does suggest that these growth rings do represent daily and monthly growth increments.

RELATIONSHIPS OF THE STROMATOPOROIDEA WITHIN THE PORIFERA

Carl W. Stock. Dept. of Geology and Geography, Univ. of Ala., University, AL 35486.

Stromatoporoids were common organisms in shallow seas from the Ordovician through Devonian. For nearly a century the majority of paleontologists believed they were an extinct order of hydrozoan coelenterates. The rediscovery of sclerosponges in the late 1960's convinced most paleontologists that stromatoporoids were some sort of sponge (Phylum Porifera). At first it was believed that the stromatoporoids should be placed in Class Sclerospongia, in that both groups possessed astrorhizal canals and a calcareous exoskeleton. Several years later it was suggested that the lack of spicules in stromatoporoids was too strong a difference for their inclusion in any existing poriferan classification, and Subphylum Stromatoporata was proposed. This treatment is similar to that accorded by some to Subphylum Archeocyatha. Systematic comparisons of the stromatoporoids with other existing sponge classes have never been made. Class Hyalospongia with silica spicules and regular growth from has little in common with stromatoporoids. Astrorhizae are present in some genera of Class Calcispongia, but calcareous spicules are always present. It is Class Demospongia which shows some remarkable resemblances to stromatoporoids. Demosponges are generally irregular in morphology and are leucon in structure. Certain genera may lack spicules and/or spongin fibers, and others have astrorhizal canals. All of these traits are characteristic of stromatoporoids. It is concluded that stromatoporoids share several characteristics with the existing

Abstracts

sponge classes. Therefore a new Class Stormatoporida is proposed, most closely related to Classes Sclerospongia and Demospongia.

HUMATE OCCURRENCE IN ALABAMA AND FLORIDA

Norman Bayne Cranford, Auburn Univ., Auburn, AL 36830.

Chemically, humate is defined as a salt or ester of humic acid. Geologically, humate is used by Swanson and Palacas (1965) in a collective sense to refer to any of the group of gel-like solid humic substances in sediments. Along the humid coastal areas of eastern Australia and the eastern United States, humate occurs as the matrix in siliceous sand and is particularly well developed in coastal deposits of Pleistocene age. This paper describes the results of re-investigation, during the months of July and August, 1978, of some of the humate locations on Choctawhatchee Bay in Florida, first described by Swanson and Palacas, and the first report of humates in Baldwin County, Alabama. The humate location on an eroded area on the Gulf side of Dauphin Island, Alabama, was also investigated and compared with humate occurrences in west Florida and Baldwin County.

MUSGROVE CREEK GAS FIELD, CENTRAL FAYETTE COUNTY, ALABAMA

Roger M. Chapman, Dept. of Geology and Geography, Univ. of Ala., University, AL 35486.

The Musgrove Creek Gas Field is located in the central part of the Black Warrior Basin in central Fayette County, Alabama. Musgrove Creek included 16 sections of T15S, R12W at the time of this study. The discovery well for the field is the Terra Resources J. C. Randolph No. 1. The well is located in Sec. 17, T15S, R12W and has a CAOF of 4600 MCF per day. The Carter Sand which reaches a maximum thickness of 30 feet in the field is the producing reservoir. It has maximum porosity of 22%, and permeability averages 500 md. The reservoir occurs at depths of 1870 to 2190 feet below sea level in the area. The Carter represents a major influx of fine-grained quartzose sandstone into the Warrior Basin from the northwest during Mississippian time. The Carter accumulated in a deltaic dominated depositional system. Delta front and re-worked delta front sands are the primary reservoirs in the field. The petroleum trap in Musgrove Creek is predominantly a stratigraphic trap.

DETECTION OF FLUORESCENCE IN FOSSIL MULLUSCS

Wayne S. Barnett. Dept. of Geology, Auburn Univ., Auburn, AL 36830.

Many fossil molluscs show fluorescence when exposed to ultraviolet light. Although fluorescence has been known in Cretaceous to Recent fossils for over 50 years its causes remain poorly understood. Recent studies indicate that organic compounds associated with the original color patterns in the shell concentrate strontium and magnesium which cause this phenomenon. Natural exposure to sunlight or artificial

Abstracts

bleaching of fossil molluscs in sodium hypochlorite usually enhances fluorescence. I have also observed that fluorescence usually does not occur in parts of shells that have not been exposed to the sun before they were collected. Color patterns are important taxonomic characters in some living molluscs. Color patterns in fossils that fluoresce are potentially important in solving many perplexing taxonomic problems of fossil molluscs. Application of this phenomenon has been limited because it does not seem to occur naturally in all shells. This study attempts to record the frequency of occurrence of this phenomenon and to develop techniques for enhancing and photographically recording fluorescence in gastropods and pelecypods.

PETROGRAPHY AND LITHOLOGY OF THE "BROOKWOOD COAL GROUP," BROOKWOOD, ALABAMA

William M. Katz. Dept. of Geology and Geography, Univ. of Ala., University, AL 35486.

The upper 150 ft. of clastic strata of the Pennsylvanian Pottsville Formation in the Black Warrior Basin of northwest Alabama is the "Brookwood Group." The "Brookwood Group," which is an informal rock term, crops out in eastern Tuscaloosa County and in extreme western Jefferson County in an area of 150 square miles. The Brookwood in part is overlain unconformably by Cretaceous Tuscaloosa Group or by high terrace deposits. The contact of the Brookwood and underlying Pottsville strata is gradational and is an arbitrary delineation based on the absence of coals. Field mapping of 52 square miles and the study of 40 sections in the Brookwood 7 1/2-minute quadrangle in Tuscaloosa County are used to describe stratigraphic relationships and lithologies present in the "Brookwood Group." The sandstones are usually massive or thinly interbedded with siltstone and can exhibit cross-bedding and graded bedding. Petrographic analysis of 25 thin sections indicates that the sandstones are medium- to very fine-grained, subarkoses and sublitharenites. The composition of a typical sandstone is quartz 54.0%, feldspar 4.4%, metamorphic rock fragments 8.1%, chert 1.9%, matrix 21.9%, carbonate cement 2.7%, muscovite 4.8%, and opaques 2.1%. The quartz grains are moderately to very poorly sorted and are subangular to subrounded. The sedimentary structures, composition and texture of the sandstones suggest upper to lower delta plain deposition. These texturally and chemically immature sandstones have seen little transportation. The source area probably was a nearby metamorphic terrain.

MORPHOLOGICAL PLASTICITY IN THE UPPER CARBONIFEROUS FORM GENUS *PECOPTERIS* BRONGNIART

Robert A. Gastaldo. Dept. of Geology, Auburn Univ., Auburn, AL 36830.

The form genus *Pecopteris* Brongniart is a dominant coal forming plant in the Upper Carboniferous sediments of the northern hemisphere. The genus is characterized by pinnatifid fronds possessing pinnules attached to the rachis by their entire base; lateral pinnule borders parallel or weakly convergent and may be decurrent at the base; a single median vein

Abstracts

arising from the rachis and ascending to near the apex; lateral veins emerging from the median vein only and remaining simple or dichotomizing. One hundred twenty-nine species of *Pecopteris* have been reported from North America. The criteria utilized to distinguish species are that of venation, pinnule shape, villosity and characteristics of the rachis with venation being deemed as the most reliable feature. However, morphological variation within a single frond may result in assignment of various parts of that frond to different species. An unusual specimen of *Pecopteris*, preserved by authigenic cementation, has been collected from the Anna Shale Member of the Carbondale Formation, Kewanee Group, southern Illinois. Examination of the specimen provides an insight into the complexity and diversity of form exhibited by pteridophytes of the Middle Pennsylvanian. At least four different laminar forms occur on progressively acropscopic pinnae. The recognition of this extreme variability, occurring within 8 cm of rachial distance, implies a high degree of morphological plasticity within Carboniferous fern taxa, and emphasizes the need for a reevaluation of taxa in the form genus *Pecopteris* Brongniart.

MINERALOGY AND CHEMISTRY OF MOLYBDENUM-RICH GOSSANS

Ed L. Schrader. Dept. of Geology and Geography, Univ. of Ala., University, AL 35486.

Oxidized Mo deposits give rise to four supergene assemblages: (1) secondary minerals absent; (2) ferrimolybdate dominant; (3) ferrimolybdate, jarosite \pm goethite; and (4) goethite and ferrimolybdate. Crystallization of ferrimolybdate was experimentally studied by variation of pH and Fe/Mo ratios in solution at S.T.P. Ferrimolybdate composition changes regularly across the pH vs. Fe/Mo field. Mo content of the material increases with a lower pH and a lower Fe/Mo ratio. The spacings of higher angled x-ray reflections increase with the Fe⁺³ content of ferrimolybdate. Thus, limited diachochy occurs in ferrimolybdate and was observed between the approximate limits of 1/1.8 (Fe/Mo) and 1/2.5 (Fe/Mo). The synthesis experiments and observations of gossan samples indicate: (1) jarosite precipitates during a period of low pH; (2) slightly Mo-rich ferrimolybdate infers a higher pH (~1.3-3.5) of the oxidizing system; (3) coexisting Fe-rich ferrimolybdate and goethite indicate still higher pH values (~3.5-5.0); (4) only goethite in a Mo-rich gossan reflects a local pH of ~5.0. Electron microprobe analyses of natural samples indicated the following trends: quartz, feldspar, and mica are low in concentration regarding trace metals found in ferrimolybdate; Ag and W are often concentrated in ferrimolybdate and Bi and Se are consistently depleted; Cu may be either concentrated or depleted in the oxide and correlates with climatic variations.

Abstracts

DISTRIBUTION OF STROMATOPOROIDS IN A LOWER DEVONIAN (KEYSER FORMATION) BIOHERM, MUSTOE, HIGHLAND COUNTY, VIRGINIA

Ann E. Holmes. Dept. of Geology and Geography, Univ. of Ala., University, AL 35486.

Growth forms of stromatoporoids are believed to be dependent on the effects of the surrounding physical environment. The distribution of these various external morphologies (including: subspherical, hemispherical, laminar, irregular, encrusting, ramose, digitate, columnar, and massive) in a bioherm outcrop near Mustoe, Virginia has been observed. Most stromatoporoids are most successful in shallow, turbulent water. Large subsphericals are generally found in high energy environments while the smaller ones are in lower energy areas. Hemispherical forms range between high energy and moderate energy. Laminar stromatoporoids seem to be associated with soft substrates, distributing the mass over a wider surface area and occur in moderately deep, both quiet and agitated, water. Irregular coenostea are apparently laminar forms subjected to sustained current direction and/or high sediment influx. Encrusting stromatoporoids inherit the general shape of the objects they encrust. Digitate and columnar growth forms are possibly the result of rapid sedimentation or an increase in sea level which could induce rapid vertical growth. Massive zones of stromatoporoids exist in the study area and are composed predominately of hemisphericals and subsphericals so intergrown that it was impossible to distinguish individual coenostea. These densely populated zones are generally restricted to shallow, rough water. Thinly branching ramose stromatoporoids are examples of the few forms that thrive in quiet water.

SEDIMENTATION AFFECTING THE NATURAL LIFE OF A LAKE IN THE WARRIOR RIVER BASIN WITHIN TUSCALOOSA COUNTY, ALABAMA

Anthony M. Malatino. Geochemical-Water Quality Research Div., Geological Survey of Ala., University, AL 35486.

Lake Tuscaloosa is a water-supply and recreation reservoir on the North River in Tuscaloosa County. Present sediment yield of the North River Basin is approximately 300 tons per square mile per year. Surface mining, construction, or other activities that severely expose the earth could drastically increase the sediment yield of the basin. For present conditions, it is estimated that the time required to completely fill the storage capacity of the reservoir with sediment is over 3,000 years. If as much as 10 percent of the North River Basin is severely exposed to erosion, the life of the reservoir might be reduced to slightly more than 200 years; and the useful life, even less. There is legislation to protect the lake from excessive sedimentation, but this legislation will require enforcement to be truly effective. Further regulations requiring a buffer zone between mining operations in the lake or tributaries to the lake, and a mandatory requirement of settling ponds to trap sediment carried by the runoff from several exposed areas may be necessary to completely protect the lake. A program of chemical and sediment monitoring could provide accurate information on the rate at which sediment is reaching the lake.

Abstracts

FORESTRY, GEOGRAPHY, AND CONSERVATION

GEOGRAPHY'S RÔLE IN ALABAMA EDUCATION

Howard G. Johnson. Dept. of Geography, Jacksonville St. Univ., Jacksonville, AL 36265.

The State Board of Education recently completed a four-year effort to revise standards for teacher education programs and to update the K-12 curriculum. One result of that effort was the elimination of geography from the K-12 curriculum. Geography was also deleted from the list of social science disciplines in which teachers might obtain certification. Had that "standards" document been approved as submitted, geography at all levels of education may well have ceased to exist in Alabama. One person, Marie Hendrix, noted the absence of geography while reviewing the proposed final draft of the "standards" document. She is solely responsible for causing the document to be revised to include geography in teacher education programs. She also was instrumental not only in having geography continued in the K-12 curriculum, but also in increasing the amount of geography to be taught. This close call demonstrates the need to establish better lines of communication among geographers and between geographers and the State Board of Education. The Society of Alabama Geographers now has a *raison d'etre*, the *Alabama Geographer* could now become our most effective means of communication.

LEGAL PROBLEMS OF THE LOW INCOME POPULATION IN NORTHWEST ALABAMA

William R. Strong, Jeffrey A. Bradley, and David Stoner. Dept. of Geography, Univ. of N. Ala., Florence, AL 35630.

In June of 1978 the Florence office of the Legal Service Corporation of Alabama, under the management of Attorney Floyd Sherrrod, contracted a study with the University of North Alabama Department of Geography focussing on the legal problems of the low income population of Lauderdale and Colbert counties. The purpose of the study was to gain information which would enable the Corporation to work more effectively in extending free legal counsel to the poor. Directed by geographers William R. Strong and Jeffrey Bradley, and with assistance of Jerome Jeffries, social worker, David Stoner, public administration and many other students, a research plan based on a questionnaire survey was formulated. The tasks involved identifying the demographic and economic characteristics of the target population, determining a representative sample, designing a questionnaire instrument, and locating clusters of low income people in both the rural and urban sectors, where the questionnaire would be administered. During the summer of 1978, 167 people were interviewed and responses were tabulated. The analysis revealed significant problems relating to governmental agencies, family, health, home ownership, housing, credit, and employment. Legal Services attorneys were also advised that a majority of people were unaware of their free services. In January 1979, the Corporation advertized a public forum at which time they discussed major problems determined by the survey. The citizen response was overwhelming. The study was extended

Abstracts

to cover four more counties, Marion, Winston, Franklin, and Lawrence, in the Northwest Alabama region.

GEOGRAPHIC LITERACY AMONG UNIVERSITY FRESHMEN

D. G. Jeane. Dept. of Geography and Emily Melvin. Dept. of Secondary Ed., Auburn Univ., Auburn, AL 36830.

The purpose of this study was to determine levels of geographic competence held by university freshmen. Among the skills tested were map orientation, the ability to make inferences from given data, the ability to deal with abstract concepts, the ability to read and interpret graphs, and map interpretation. A second purpose was to determine freshman attitude concerning secondary school and university geography courses. The population investigated was a representative sample of the 1978 entering Auburn University freshman class; 21 percent of the freshman class participated for a total of 634 responses. From the study it is concluded that entering freshmen at Auburn University demonstrate a noticeable lack of ability to utilize geographical skills and concepts effectively. An additional conclusion is that exposure to geographical concepts and skills has not had lasting effect. It is evident that there is a need for additional efforts to incorporate geographical objectives into the elementary and secondary school curriculum. It is further suggested that results of the study from Auburn University mirror similar situations at institutions of higher learning in Alabama and throughout the southeastern United States, at least.

GEOGRAPHY CURRICULUM CHANGES IN ALABAMA COLLEGES, 1957-1977

David C. Weaver. Dept. of Geology and Geography, Univ. of Ala., University, AL 35486.

There are indications in the geographic literature of a shift in emphasis in geographic studies from traditional concerns such as regional, historical and physical topics, to socio-economic issues and technical applications. Little has been written, however, concerning the expression of such trends in the college curriculum. This paper discusses changes in the course structure of geography programs in Alabama, based on data derived from the Directory of College Geography of the United States. The study indicates that while regional courses have declined in recent years their presence remains strong, and that while techniques courses continue to expand their numbers remain surprisingly small when related to total course offerings.

TAKE STOCK!--A MISLEADING WORD

Wilbur B. De Vall. Proxy Services Ltd., Auburn, AL 36830.

Communication skills are essential when dealing with the public. The spoken word is most often used when individuals present topics before groups. It is essential that terminology used by the speaker be

Abstracts

understood by the audience. This is seldom the case. A good example of a simple word with more than thirty different meanings is STOCK. The more common meanings could be listed by the average citizen to include an investment, livestock, materials on a shelf, root stock used in grafting, or planting stock as used by the forester to mean seedlings from a nursery used in afforestation or reforestation of land. It becomes apparent that when addressing an audience of bankers, garden club members, cattlemen, foresters, and others the meaning of common words may need explaining when words similar to STOCK are used.

EMPLOYMENT PROFILES OF ALABAMA COUNTIES

Cyrus B. Dawsey, III. Dept. of Geography, Auburn Univ., Auburn, AL 36830.

The location of manufacturing groups in Alabama is a topic which has largely been ignored. The few studies which have been done have been highly localized, have used ill-defined inclusion criteria and boundaries, or have developed explanations using evolutionary rather than theoretical frameworks. This paper describes the county by Alabama employment dependence on eleven major manufacturing activities. In order to show the extent to which a county is dependent on an industry, location quotient rather than absolute values were mapped. These maps show that significant patterning exists in the spatial distribution of the industries, and some of these patterns conform to what might be expected given the arrangement of raw materials, labor, and transport requirements. Furniture, lumber and wood is dominant in forest areas, metals in the coal and iron belt, textiles in eastern rural counties, and chemicals along the major rivers. A second objective of the study was to examine the extent to which the manufacturing groups were attracted to or repelled from the same counties. Positive association was found between several pairs including among others: metals-machines, wood product-textiles, and transportation equipment-chemicals. This study was suggestive of what might be done in a more thorough project.

RESIDENTIAL ATTITUDES TOWARD A PROPOSED HIGHWAY ROUTE

Thomas F. Baucom. Dept. of Geography, Jacksonville State Univ., Jacksonville, AL 36265.

The relationship between proximity to the proposed North Atlanta Parkway in Atlanta, Georgia and residential attitudes toward this facility was examined with respect to two hypotheses. Favorable attitudes toward the expressway were expected to increase with distance from the proposed route. Unfavorable attitudes were expected to decline with distance. An attitude index was developed and the derived indices analyzed with respect to both straight-line and road distances using rank correlation tests. Findings confirmed the hypotheses and suggested a distance limit of approximately 3,000 feet, under which the hypotheses held and beyond which distance had no significant effect upon residential attitudes.

Abstracts

THE EFFECTS OF THE 1960'S ON HOUSING QUALITY FOR BLACKS IN ALABAMA

Susan R. Stephenson. Dept. of Geography, Jacksonville State Univ., Jacksonville, AL 36265.

Conditions are generally believed to have changed dramatically for Blacks in the South--The 1960's are noted as a time of reform in civil rights. Although absolute levels of education for Blacks in Alabama rose during this period, the effect of education on the quality of their housing did not increase significantly.

SOLAR ENERGY HEATING IN A CLOUDY CLIMATE

Oskar M. Essenwanger. Research Directorate, Tech. Lab., US Army Missile Research & Dev. Command, Redstone Arsenal, AL 35809.

Solar energy increases in importance with the decrease of available fossil fuels. Solar energy in home use is largely suitable for air conditioning, heating water, and space heating. Today solar energy air conditioning and water heating systems are developed to the point that they are cost effective, although some improvements in performance can still be expected. Solar space heating systems are commercially available, too. By and large, they provide only partial heating energy during the winter in a cloudy climate. The critical months are December and January where the sun has its lowest position in the sky and solar energy is not always available on the coldest days when it is needed most. Based on a previously developed concept, the author has investigated the heating requirements during the last three winters in Huntsville as an example of space heating in a cloudy climate. The available solar energy depends on the size of the collector area and the average daily expectation of available energy. The larger the collector area the lower can be the daily expectation. A solar space heating system designed for 3 days' energy storage capacity and a daily expectation of 190 Langleys (January average) could provide 77% of the space heating requirements during winter while a system with unlimited storage capacity would have added only 3%. In January both the 3-day and unlimited storage systems would have provided 62% of the heat for the coldest of the 3 winters, 1977/78. Consequently, a system should be designed for a lower daily expectation than 190, e.g., 140, or the storage reserve must be full at the beginning of the winter. (190 Langleys require a reserve of 27 days.) Otherwise, a reserve capacity of more than 3 days would add little to solar space heating.

A SMALL CITY'S EXPERIENCE WITH ARCHITECTURAL ZONING

Ted Klimasewski. Dept. of Geography, Jacksonville State Univ., Jacksonville, AL 36265. Lynn Causey. Tech. Advisor, City of Jacksonville, Jacksonville, AL 36265.

Many small towns in Alabama are experiencing economic growth which substantially alters the local landscape. Conversion of the landscape from open-space to asphalt, buildings and signs symbolizes progress and

Abstracts

financial gain rather than reflect aesthetic values. The lack of concern for landscape aesthetics, according to architects and geographers, has an adverse impact upon the psychological well-being of local people. In small towns, zoning is the primary mechanism of land-use control. Once a site is rezoned, however, there is little control over adverse landscape change. The only alternative is architectural zoning which maintains control over a parcel's land use and visual impact.

AN URBAN FORESTRY PLAN FOR ALABAMA COMMUNITIES

Steven R. Sax. Northwest Ala. Council of Local Governments, Muscle Shoals, AL 35660. Tommy H. Patterson. Ala. Forestry Comm., Florence, AL 35630.

Environmental awareness has increased the concern for trees in an urban area. These trees play a vital role in a community by providing shade, aesthetics, noise abatement, oxygen generation, air purification, erosion control, wildlife habitat, and a psychological sense of community. Various methodologies were reviewed in order to develop an urban forestry plan for Alabama communities. An inventory of city maintained trees was made for a selected study area. This inventory provided data on tree species, size (diameter), and relative condition. Future activities of the planning process will include a canopy analysis, review of existing urban forest conditions for the study area, and specific recommendations to implement the plan.

THE USE OF SEQUENTIAL AERIAL PHOTOGRAPHY IN THE ANALYSIS OF URBAN GROWTH: THE CASE OF TUSCALOOSA, ALABAMA, 1938-1978

Frank D. Huttlinger and Thomas J. Kallsen. Dept. of Geology and Geography, Univ. of Ala., University, AL 35486.

Since 1938 the availability of periodic air photo coverage of much of the United States permits a detailed analysis of patterns of urban growth. In this study air photo coverage of Tuscaloosa, Alabama was examined for the years 1938, 1956 and 1978. Residential areas of cities normally account for more land than any other single urban use. It would appear that the type of land that lends itself to intensive urban development is (1) well-drained, (2) accessible to shopping centers and other places offering urban services, (3) removed from areas of industrial "blight," and (4) held in relatively large ownership units. By combining reference to the air photos with examination of both county plat books (showing land ownership) and topographic maps, the role of these factors in the urban growth of Tuscaloosa can be evaluated.

Abstracts

PHYSICS AND MATHEMATICS

FLUORESCENCE OF MIXTURES OF He, Kr, Xe, NF_3 and UF_6

Michael Monahan, John Williams, and Quincy Murphree. Dept. of Physics, Auburn Univ., Auburn, AL 36830. Thomas G. Miller. US Army Research and Dev. Command, Redstone Arsenal, AL 35809.

Fluorescence quanta emitted by the decay of molecular excited states may be wavelength, or time, resolved via a single photon counting monochrometer. The time integrated wavelength spectra are subsequently integrated over the fluorescence wavelength band of interest and normalized to proton beam current to obtain a relative measure of fluorescence intensity produced in a constant length of the proton beam path in the gas cell. The variation of this intensity with partial pressures of the component gases then gives information on optimum gas mixture and pressure for production of fluorescence in the given wavelength band.

NAKED EYE DETERMINATION OF THE PLANE OF POLARIZATION: A CLASSROOM DEMONSTRATION OF A LATENT CAPABILITY

W. J. Reid. Dept. of Physics, Jacksonville State Univ., Jacksonville, AL 36265.

The ability of the unaided human eye to detect the plane of polarization in visible light has long been known. Discovered over a hundred years ago, this visual phenomenon, known as "Haidinger's Brush," has attracted little attention. The author will display simple apparatus consisting of a photoflood and reflector, a white screen, and a sheet of polaroid, which aid in conditioning the observer's eye to view the phenomenon even in weakly polarized sky light.

EXPERIMENTAL DETERMINATION OF NANOSECOND NUCLEAR LIFETIMES

J. E. Gaiser, R. C. Harper, and W. L. Alford. Dept. of Physics, Auburn Univ., Auburn, AL 36830.

A method is described to measure the lifetimes of metastable nuclear states in the nanosecond regime. Energy and timing information are obtained by the use of Ge(Li) detectors with constant fraction discrimination. Experimental details will be presented and the results as applied to the decay of the $5/2+$ first excited state of ^{111}Cd will be presented.

PRECISION NEUTRON DOSIMETRY WITH CF-252

C. G. Hudson. School of Public Health, Univ. of Mich., Ann Arbor, MI 48109. H. C. Cobb. Dept. of Elec. Engineering, Auburn Univ., Auburn, AL 36830.

Californium-252 is used as a neutron source to test governmental, commercial, and industrial dosimeter processors. Design parameters of the

Abstracts

irradiation facility, irradiation timing and control electronics, and the electro-mechanical source positioning system are given. The Cf-252 source will be used to irradiate film badges and TLD's supplied by the processors.

$^{58}\text{Ni}(n,d + n,pn + n,np)^{57}\text{Co}$ REACTION CROSS SECTION AT 14 MeV

Laura H. Allen. Dept. of Physics, Auburn Univ., Auburn, AL 36830.

A cross section measurement of the $^{58}\text{Ni}(n,d + n,pn + n,np)^{57}\text{Co}$ reaction is complicated by the contributions of the $^{58}\text{Ni}(n,2n)^{57}\text{Ni}$ activity. To circumscribe this difficulty, an absolute cross section of 27.9 mb for the (n,2n) reaction was measured and substituted into the cross section equation from which the (n,d + n,pn + n,np) cross section was then calculated. Preliminary results yield a value of ~ 400 mb for neutron energy of 14.3 MeV.

AN OVERVIEW OF THE PERSONNEL DOSIMETRY PERFORMANCE TESTING STUDY

Glenn Hudson. School of Public Health, Univ. of Mich., Ann Arbor, MI 48109.

A two-year pilot study to determine the feasibility of the HPSSC Standard for a mandatory testing program of personnel dosimetry processors was begun on September 28, 1977. Each participating processor was to submit dosimeters for two tests during the pilot study. The first test is being offered from November, 1978 through April, 1979. A total of 58 processors have reported their measured radiation doses to us. The performance of the processors and causes, attributable to the processors, for the relatively poor performance of most processors is summarized. The overall passing rate for Test #1 is 24%.

DIFFERENCE EQUATION SOLUTIONS FOR HOPPING TRANSPORT OF CHARGED PARTICLES THROUGH SOLIDS AND BIOLOGICAL MEMBRANES

A. T. Fromhold, Jr. Dept. of Physics, Auburn Univ., Auburn, AL 36830.

Difference equations provide a more natural representation than do differential equations for the hopping conduction of charged particles in material media. The discreteness of a material medium on an atomistic scale can lead to large physical effects such as non-ohmic currents in the presence of large electric fields. A steady-state expression for the current has been obtained by summing the coupled difference equations for transport of a single species in the limit of arbitrarily large values of the space charge density due to the mobile carriers, with a concentration gradient across the layer included. The transient response has also been worked out, but only in the homogeneous field limit. It is concluded that the combination of high electric fields with the natural microscopic discreteness of the diffusion medium can result in readily observable nonlinear electric field effects which

Abstracts

increase approximately exponentially with the separation distances of the discrete energy barriers.

EFFICIENCY CALIBRATION OF A GERMANIUM DETECTOR

T. V. Reiff and M. J. Mareno. Dept. of Physics, Auburn Univ., Auburn, AL 36830.

A brief review is given of radiation detection. The efficiency calibration of a Ge(Li) detector is described with results being given for both the total efficiency and photopeak efficiency. Standard gamma-ray sources from the National Bureau of Standards were used to accomplish the calibration. Factors affecting the accuracy of the results are discussed.

A RATIONALE FOR TORNADO FORCE ESTIMATION

George W. Reynolds. Air Quality Branch, TVA, Muscle Shoals, AL 35660.

The directions of the destroying forces and the extent of the damage are important when estimating the magnitudes of tornado forces from tornado damage patterns. Onsite investigation of 15 tornado damage paths has indicated that the speed of translation is an important component of the total wind speed. Evidence supporting this premise is presented. A collateral implication is that tornado wind forces are less than they are often assumed to be, and that the differences between the complete destruction and survival of a building may often rest in relatively small differences in the capability for resistance.

COMPUTER AIDED ANALYSIS OF INTERFEROGRAMS

A. H. Werkheiser. US Army Missile Command, Redstone Arsenal, AL 35809.

The most important part and the most difficult part of computerized interferometric analysis is digitizing the interferograms and storing the information on a permanent medium. A series of computer programs were written and tested for this purpose and for the purpose of analyzing the resultant data. Typical results are shown. An example is also shown on how the analyzed data may be further used for system studies of high energy lasers.

ELECTRICAL PROPERTIES OF AMORPHOUS SILICON

Laura H. Allen. Dept. of Physics, Auburn Univ., Auburn, AL 36830.

Thin film samples were prepared by a getter sputtering technique. The dc and ac conduction and dielectric constant were measured over a temperature range of 1.5-273°K and a frequency range of dc-100khz. Results were compared with the theory predicted by Mott and others.

Abstracts

SUBMILLIMETER PROPAGATION THROUGH CLEAR AIR

Dorothy Anne Stewart. Research Directorate, Tech. Lab., US Army Missile Research & Dev. Command, Redstone Arsenal, AL 35809.

Water vapor is the principal absorber of submillimeter radiant energy in the lower atmosphere. Absorption near line centers is hundreds or thousands of dB/km for a standard absolute humidity of 7.5 grams per cubic meter, and in the real atmosphere the absolute humidity can be over three times the standard value. Transmission is greater in window regions between strong absorption lines. For example, absorption in the window centered near 880 micrometers is near 10 dB/km under standard conditions. This is considerably greater than traditional theoretical predictions of absorption by water vapor molecules. Different investigators explain this excess absorption by water dimers, clusters of water molecules, scattering by dust, and continuum absorption in the far wings of several absorption lines. Measurements of absorption of the wavelength 894 micrometers have been made on Redstone Arsenal by the Research Directorate. These measurements indicate that absorption depends upon water vapor content, temperature, and amount of solar radiation. An additional unexplained variation also occurs.

ABSOLUTE VALUE AND INEQUALITIES

W. L. Furman. Spring Hill Col., Mobile, AL 36608.

This is an expository presentation of inequalities and absolute value.

MATHEMATICIANS AND RELATIVITY

Juan C. Aramburu. Dept. of Mathematics, Univ. of N. Ala., Florence, AL 35630.

The invigorating effects of the theory of relativity on several branches of mathematics are well known. The contributions to relativity made by mathematicians are less known, and some of them are described in this paper. It begins with Poincare and Minkowski, and ends with the papers presented at the winter meeting of the American Mathematical Society held in Biloxi, Mississippi, in January 1979.

ON DELAYED AVERAGES OF BROWNIAN MOTION IN BANACH SPACES

Mou-Hsiung Chang. Dept. of Mathematics, Univ. of Ala. in Huntsville, Huntsville, AL 35807.

Let $\{W(t): t \geq 0\}$ be μ -Brownian motion in a real separable Banach space B , and let \bar{a}_T be a non-decreasing function of T for which (i) $0 < \bar{a}_T < T$ ($T > 0$) (ii) \bar{a}_T/T is non-increasing. We establish a Strassen's limit theorem for the net $\{\xi_T: T \geq 3\}$, where

$$\xi_T(t) = (W(T + t \bar{a}_T) - W(T))/\sqrt{2} \bar{a}_T [\log(T/\bar{a}_T) + \log \log T], 0 \leq t \leq 1.$$

LINEARIZED APPROXIMATIONS OF QUASILINEAR HYPERBOLIC SYSTEMS

L. M. Foster. Dept. of Mathematics, Univ. of Ala. in Huntsville, Huntsville, AL 35807.

We approximate the solution of a first order quasilinear hyperbolic Cauchy system

$$(1) U_t = A(t,x,U)U_x + F(t,x,U), U(0,x) = f(x), (t,x) \in I \times R$$

by the solutions of linear time dependent first order hyperbolic systems

$$(2) W_t^{m,k} = A^{m,k}(x)W_x^{m,k} + F^{m,k}(x), (t,x) \in [mk, (m+1)k] \times R$$

where $k^{-1} \in Z^+$ and $m = 0, \dots, k^{-1}-1$. (2) has Cauchy data $W^{m,k}(mk,x) = W^{m-1,k}(mk,x) + \phi^{m,k}(x)$ where $\phi^{m,k}$ is an error function of size $O(k^3)$ in L^∞ ; $A^{m,k}$ and $F^{m,k}$ are functions of the initial data $W^{m,k}(mk, \cdot)$. We show $D^\alpha(U - W^{m,k}) = O((m+1)k^{3-|\alpha|})$ in L^∞ for $|\alpha| \leq 1$. The numerical approximation of $W^{m,k}$ is considered and a numerical experiment is given.

GEOMETRIC PROPERTIES OF DOUBLY STOCHASTIC MATRICES

Peter M. Gibson. Dept. of Mathematics, Univ. of Ala. in Huntsville, Huntsville, AL 35807.

Let Ω_n denote the set of all $n \times n$ nonnegative doubly stochastic matrices, that is, $n \times n$ real matrices $X = (x_{ij})$ such that $x_{ij} \geq 0$ and $\sum_{k=1}^n x_{ik} = 1 = \sum_{k=1}^n x_{kj}$ for all $i, j = 1, \dots, n$. It is well known that Ω_n is a closed bounded convex polyhedron in Euclidean n^2 -space whose dimension is $(n-1)^2$ and whose vertices are the $n \times n$ permutation matrices. A number of other recently discovered properties of Ω_n are presented here with emphasis given to those that relate to the permanent function.

SUPERFIGURES REPLICATING WITH POLAR SYMMETRY

Jack Giles, Jr. Dept. of Mathematics, Univ. of Ala. in Huntsville, Huntsville, AL 35807.

A *replicating figure* is one that tiles itself. Methods will be demonstrated for producing such figures bounded by fractals having a replicating pattern symmetric about a pole.

Abstracts

SOLUTION CONFORMATION OF PEPTIDES BY NUCLEAR OVERHAUSER EFFECT

D. H. Huang, W. Atkinson, and N. R. Krishna. Dept. of Physics and Comp. Cancer Center, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The nuclear Overhauser effect (NOE) enhancements are very sensitive to the molecular conformations, and can be used to select from a set of possible conformations for a peptide or a protein the particular conformation (or a group of conformations) most consistent with the experimental data. The cyclic decapeptide antibiotic gramicidin S is chosen as a model in this study. The first nine low energy conformations of gramicidin S proposed in literature are considered. The theoretical NOE enhancements have been calculated for each conformation and compared with the experimental data obtained in our laboratory, as well as with that available in literature. By using statistical hypothesis tests involving the Hamilton R-factor ratio criterion, certain conformations have been rejected as inconsistent with the experimental data, while the others have been shown to provide a very good description of the observed enhancements.

DOSE DISTRIBUTIONS FROM AN INTRAUTERINE APPLICATOR

Nora C. T. Lin. Dept. of Physics, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

When radioactive sources are inserted in a patient's body, it is important to know the dosage distributions from the sources so that the clinician can choose a satisfactory treatment plan. Improved calculations and display for dose distributions from sources loaded in an intrauterine applicator have been made. Using this new method, the exact source positions can be reconstructed from two orthogonal x-ray films. The isodose curves produced from the sources can be plotted in planes which can be selected to delineate the full three-dimensional dose distribution.

HEAT TRANSFER IN HYPERTHERMIA

Shao-Hua Chao. Dept. of Physics, The Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Solutions of the time dependent bio-heat transfer equations are presented for tissue systems with geometrical symmetry. These solutions pertain to model systems which represent different types of tissue heated with a radio frequency source of long wavelength. An analysis is made of the effect of parameters including the blood flow, thermal conductivity and diffusivity on the nature of the solutions. From the analysis of solutions for different parameters, we find out that the blood flow is the main cooling mechanism. We can estimate the temperature distributions for different points of the tissue.

Abstracts

COUNTING COSMIC RAYS WITH MICROCOMPUTERS

Mary E. Mancil. Dept. of Physics, Auburn Univ., Auburn, AL 36380.

Cosmic rays are random processes, and the distribution of the time intervals between these events are exponential. The cosmic rays were detected by two large NaI(TL) scintillation counters. A microcomputer was programmed to measure the interval between these events, recording the distribution for each sidereal hour. A complete description of the hardware and some software is included.

INDUSTRY AND ECONOMICS

AN ANALYSIS OF ELECTRICITY DEMAND BY WIDOWED AND RETIRED PERSONS IN ALABAMA

A. Wayne Lacy. School of Business, Auburn Univ. at Montg., Montgomery, AL 36117. Donald R. Street. Dept. of Economics, Auburn Univ., Auburn, AL 36830. Don Irby. Former Research Associate.

This study includes an electricity demand model for a special component of society, the widowed and/or retired segment of the population. The work includes results in terms of electricity use and elasticity coefficients for a sample of 528 individual consumer units for a five and one-half year period. The study complements a previous study for the general population. Data used were from Birmingham, Montgomery, and Mobile. The elasticity and use data were segmented by eight different income categories. Data were presented on the annual mean use of electricity for the sample groups. Unweighted marginal price elasticity coefficients for the combined sample varied from -1.14 for the lowest income group to -.38 for the highest income group. These coefficients were higher (in absolute terms) than the comparable data from the general population, as theory would suggest. A double-weighted price elasticity coefficient for all income levels of the combined sample was -.791 for the widows and retired customers in comparison with a coefficient of -.45 for the general population. The coefficients were weighted by average use of each income class and by percentage of total customers in each income class for the state. Additional elasticity coefficients were calculated for a lagged response to the size of the electric bill, for a patriotism response to Presidential appeals to conserve electricity, for a trend measure, and for a weather variable. Separate coefficients were calculated by customer groups for the different variables.

THE ANALYSIS OF THE EFFECT OF CONSERVATIONS ON THE DEMAND FOR ELECTRICITY

J. F. Vallery and Billy P. Helms. Univ. of Ala., University, AL 35486.

There has been considerable attention to the economics literature and the utility rate hearings concerning that reduction in usage that should occur due to the large rate increases that have been instituted since

1973. Utilities have reported some aggregate data that have shown that there has been some conservation, but to date there has been little attention directed toward detailing the actual level of conservation in residential usage. The data base included the results of 6,000 personal interviews in a 1972 survey and a survey in 1977 covering over 3,000 customers. Both surveys collected data on appliance saturation, number of people in the household, energy use, and similar subjects. The latter survey collected more extensive information on economic factors and conservation. There are several factors influencing changes in electrical energy consumption by households. These include: a) Changes in usage patterns within the housing population; b) Changes in the saturation of specific appliances; c) Changes in the composition of the housing population. These factors are analyzed using principal component regression to circumvent the multicollinearity among the regressor variables. From the study we can make the following conclusions: 1) there has been conservation in the use of electricity for air conditioning both in central units and in window units; 2) there has been conservation in the use of electricity for heat pumps; 3) there has been conservation in the use of electricity to heat water but at much lower levels.

A USE OF COVARIANCE ANALYSIS IN THE STUDY OF ECONOMIC
GROWTH PATTERNS IN TWO ALABAMA SMSAS

Jerry R. Shipman and Vernon Smith. Dept. of Mathematics, Ala. A&M Univ., Normal, AL 35762.

A covariance analysis model was used to statistically analyze economic growth patterns in two Alabama Standard Metropolitan Statistical Areas (SMSAs), based on employment data over three industrial categories--manufactured durable goods, manufactured nondurable goods, and nonmanufactured goods and services. In addition, a projection equation, derived from the parameters of the covariance analysis model, was used to predict employment statistics for the SMSAs for each industrial category. Based on the results of the analyses, the covariance analysis model was adjudged adequate for describing the economic growth trends of the SMSAs.

USING THE GRAFTED POLYNOMIAL TO ESTIMATE CROP RESPONSE
SURFACES FOR AGRICULTURAL LIME

W. J. Free. Div. of Agr. Dev., TVA, Muscle Shoals, AL 35660. Harry H. Hall, Dept. of Agr. Econ., Univ. of Kentucky, Lexington, KY 40546.

Excessive soil acidity has long been recognized as one reason soils become unproductive. Crop response to lime appears to follow a rapid upward path when soil pH levels are below some critical level; then yield response levels off--almost flat--when lime is applied to raise the pH above the critical level. This type response surface has been graphed freehand, but most mathematical formulations tend to understate the yield response at the critical point and overstate the response at high lime rates when pH is above the critical point. This has

significant economic implications if farmers attempt to choose production inputs economically. The grafted polynomial provides a mathematical technique that better approximates the "critical" turning point and the slope of the surface beyond that point. This mathematical equation can be used for economic interpretations by converting to marginal value product and equating marginal cost with marginal revenue and marginal return per dollar spent for agricultural lime with marginal returns per dollar spent on other production inputs. These economic evaluations can then be used for advising about farm management decisions.

THE BUSINESS CLIMATE IN ALABAMA: A COMPARISON WITH OTHER STATES

Sandra Douglas and A. Wayne Lacy. Auburn Univ. at Montg., Montgomery, AL 36117.

A myriad of factors are responsible for the location of industry including the movement of manufacturing employment from one region to another. Environmental factors such as natural resources, climate, and the potential for a continuous supply of energy are a primary consideration. Institutional factors such as taxes, public spending, and laws also have had some bearing, especially when several regions have comparable natural environments. This study, an adaptation of a study compiled by the Fantus Company, compared the institutional factors which affect the business climate in Alabama with the institutional factors of other states. The factors under investigation included taxes affecting business, expenditures (state and local) affecting business, and laws affecting business. The states were ranked in relation to other states with the state with taxes, spending, and laws more favorable to business ranking lowest numerically. The results from this ranking were compared to the gain or loss in capital investment for new and expanding industries as well as the net gain or loss in manufacturing employment. Finally, the results of the Fantus study were compared to the results of this study to indicate the differences caused by the adaptation.

AN ECONOMIC IMPACT OF THE UNIVERSITY OF NORTH ALABAMA ON LAUDERDALE AND COLBERT COUNTIES, 1978

Michael Butler and William Stewart. Univ. of N. Ala., Florence, AL. 35630.

The study, which began in the summer of 1978, measured four major sources of economic impact by the University on the two counties. They are the impact of UNA and UNA-related expenditures, and the impact on local government, local employment and local financial institutions. The report shows that UNA's faculty, staff and students spent approximately \$12.8 million in the two counties during the 1977-78 school year. Of this amount, UNA spent, excluding payroll and scholarships, approximately \$3.1 million, faculty and staff \$2.3 million, and students \$7.3 million. The \$12.8 million expenditure that is directly attributable to UNA also generated secondary flows of income in the area. The benefits resulting from the expenditure multiplier effect increased the impact of the \$12.8 million to a minimum of \$23 million. The study

Abstracts

reveals that UNA employed 439 persons during the 1977-78 school term as faculty and staff. In addition, 1,256 jobs were created in the local area as a result of University and University-related expenditures. The net impact was 1,685 jobs created in the community by the presence of UNA. When average faculty, staff and student deposits are included, with University deposits, an approximate increase of \$8.7 million in the credit base of local financial institutions occurred as a result of UNA. University-related persons received approximately \$869,000 in local government municipal and public school services during the 1977-78 school year. The presence of the University resulted in expenditures for local government services of \$119,000 in excess of tax revenues from UNA-related personnel.

INFORMATION NEEDS AND SOURCES OF ALABAMA FARMERS 1976

J. L. Stallings and G. L. Harrison. Dept. of Ag. Ec. and Rural Soc., Agri. Exp. Station, Auburn Univ., Auburn, AL 36830.

A mail survey was sent to 1,335 Alabama farmers in 1977 asking them what kinds of information they needed for their farm operations and their sources. About a third of the questionnaires were returned (436) which is usual for a mail survey of this type. Analysis was made by nine commodity groups, different gross income levels, education levels, and age of operator. Livestock prices were the single most important category of information reported needed, followed by kinds and amounts of fertilizer to use. Other important categories of information needed were livestock disease information, kinds and method of application of insecticides, kinds and method of application of herbicides, new farm practices, Federal Government programs, type of farm machinery to buy, machinery repair methods, and new crop varieties. Farm magazines were the single most important source of information and were mentioned by nearly 85 percent of the farmers. They ranked high for a wide variety of kinds of information. They were also used more frequently than any other source. Radio, newspapers, and television also were important sources for a wide variety of livestock and crop price information. There was little difference in use of different sources of information by commodity groups except that peanut farmers were the highest average users of all sources of information and poultry farmers were the lowest. By income levels, generally, use of all sources increased as incomes rose. This was also true of education levels. There was little difference in use of different sources of information by age levels.

OBJECTIVE CREDIT SCORING--AN ANALYSIS OF AGRICULTURAL BORROWER CHARACTERISTICS

Johno B. Weed and William E. Hardy, Jr. Dept. of Ag. Ec. and Rural Soc., Auburn Univ., Auburn, AL 36830.

Agriculture as an industry has under-gone many changes in the past decade. The most substantial change has been the increase in the use of borrowed capital for capital expenditures and production expenses. Though total investment has increased, net farm income has not increased

as greatly creating a higher relative debt burden for farm operators. Agricultural lenders are now encountering the difficulties associated with increased number of loans, increased size of loans, and increased debt burden of borrowers. The purpose of this study was to develop an objective credit evaluation technique based on loan repayment ability characteristics of farm borrowers. Results indicated that farm borrowers were a homogeneous group for classification purposes, therefore, only one classification function was needed. Two variables, total liabilities divided by total assets and annual loan repayment anticipated divided by total assets, were found significant for discriminating between those borrowers that will have repayment difficulty and those that will not. The classification function correctly classified an average of 85 percent of the loans in the original sample and test sample. The original classification function was modified to an application technique that could be used for classification of loan applications and existing loans. A table of cut-off values was derived for different percentages of problem loan misclassification to allow lending institutions to incorporate misclassification cost and management preference into the classification technique. The table of cut-off values and its associated illustration point out the trade-off between correct classification of problem and acceptable loans.

SUSPENSION FERTILIZERS--THE RESPONSE OF YOUNG TENNESSEE VALLEY FARMERS TO LABOR AND CAPITAL CONSTRAINTS?

Thomas H. Foster and Ronald J. Williams. TVA, Muscle Shoals, AL 35660. G. L. Harrison and Neil R. Martin. Dept. of Ag. Ec., Auburn Univ., Auburn, AL 36830.

Suspension fertilizers are a relatively new innovation currently being introduced in the Southeast. These fertilizers are opaque fluid fertilizers containing undissolved crystals held in suspension by a clay gelling agent. While some farmers have accepted this innovation, others have continued with traditional materials--dry or clear liquid materials. The Tennessee Valley Authority carries out national educational and demonstrational activities to: (1) introduce new and improved fertilizers, (2) promote improved fertilizer products and processes, and (3) promote efficient fertilizer use. As part of this effort, in collaboration with Auburn University, this project encompasses two major objectives: (1) To identify the characteristics of fertilizer users in the Tennessee Valley area of Alabama and (2) to determine differences in characteristics between suspension and non-suspension users in the study area. Data from personal interviews were subjected to multiple regression analysis, test of statistical significance, and measures of association to determine factors affecting fertilizer selection. Preliminary results indicate that there are significant differences between suspension and non-suspension users. The suspension users tend to be new entrants into farming and are using suspension fertilizer and the attendant package of services to relieve labor and capital constraints.

Abstracts

PROFILE OF LIME VENDORS IN NORTH ALABAMA

W. S. Stewart. Univ. of N. Ala., Florence, AL 35630. W. J. Free. Div. of Agr. Dev., TVA, Muscle Shoals, AL 35660.

The market structure of agricultural lime vendors is described for two major agricultural counties--Limestone and DeKalb. Market conduct and performance are also discussed and related to the market environment of the two counties. The structure of the lime industry was dramatically different in the two counties. All commercial bulk lime vendors were interviewed in each county. In DeKalb County there were 10 commercial bulk lime spreaders and an additional 40-50 farmers who owned spreader trucks and spread their own lime. In Limestone there were only five commercial bulk lime spreaders and only a few farmers owned spreader trucks and spread their own lime. Supplies of lime were available to spreaders and farmers from quarries located either within the county or within a few miles in adjoining counties. Conduct and performance also differed between the two counties. Vendors in Limestone County applied an average of almost 19,000 tons annually. In DeKalb County the average was about 2,000 tons. In DeKalb County lime accounted for less than 10 percent of total business volume for all vendors except one, while in Limestone County lime accounted for more than 10 percent of business volume in three of the five vendors and over 50 percent for two of them. These differences appear to be associated with size of farming operation, cropping patterns, and aggressiveness of vendors in encouraging lime use.

THE INFRA-STRUCTURE NEEDED TO SUPPORT THE POULTRY INDUSTRY IN THE TARCOG AREA

Maceo Leonard and W. J. Free. Div. of Agr. Dev., TVA, Muscle Shoals, AL 35660.

This is the first in a series of reports on the infra-structure needed to support the poultry industry in the TARCOG area. This study was requested by representatives in the TARCOG area. The TARCOG area is located in the northeast corner of Alabama. It consists of five counties (DeKalb, Jackson, Limestone, Madison, and Marshall Counties, Alabama, and Ardmore, Tennessee), four of which are predominantly rural. The single county with a majority of urban residents is Madison which includes the principal city of Huntsville. TARCOG represents Top of Alabama Regional Council of Governments. The purpose of this study was: (1) to discuss current and future poultry production in the TARCOG area, (2) to determine the supporting industries needed by the poultry industry, (3) to determine the supporting industries currently in the area, (4) to determine the need for additional supporting industries in the area, and (5) to evaluate the potential for new firms locating in the area. In 1974, 7,000 farms produced 13 million layers in Alabama; in the TARCOG area 900 farms produced 3 million layers. Also, 3,000 farms in Alabama produced 69 million broilers; in the TARCOG area 700 farms produced 14 million broilers. Poultry and poultry products represent 47 percent of the total value of all agricultural products sold in the area. Generally, a majority of supporting industries are located in

Abstracts

Alabama. Specifically, there are not many supporting industries in the TARCOG area. We are investigating opportunities for locating supporting industries in the TARCOG area.

ECONOMIC EFFICIENCY OF VEHICLE ROUTING AND SCHEDULING SYSTEMS

William E. Hardy, Jr. Dept. of Ag. Ec. and Rural Soc., Auburn Univ., Auburn, AL 36830.

Most portions of the production and marketing system receive criticism for product price increases during an inflationary period. Middlemen are often cited as being responsible for a large percentage of increased food costs during recent years. These individuals receive almost 60 percent of the retail cost of farm produced products. Because of this substantial share received by middlemen, increased efficiency in their operations could have significant effects on future food prices. The research results presented in this paper look at cost savings that might be realized through more efficient vehicle routing and scheduling systems. Two improved routing alternatives are examined and significant savings are shown. The first assumes that routes are developed using the common practice that trucks would follow basically the same route each day with customers always being served by the same driver. Annual operating costs could be reduced by eight percent from the level currently being realized by the example case study firm. The second routing alternative permitted each delivery day to be considered independently. The improved network with this assumption gave estimated annual savings of 17 percent from the existing system, a substantial reduction which should be considered by all management charged with such operations.

THE RURAL LAND MARKET IN MAJOR AGRICULTURAL AREAS OF ALABAMA

John L. Adrian. Dept. of Ag. Ec. and Rural Soc., Auburn Univ., Auburn, AL 36830.

Differences in the structure of rural real estate markets in three primary agricultural areas of the State were analyzed. These areas were classified by soil characteristics and were identified as the Black Belt, the Southeastern Lower Coastal Plain (Wiregrass) and the Limestone Valley (Tennessee and Coosa River basins). Rural real estate in the Limestone Valley had the highest values with Black Belt and Wiregrass real estate commanding similar prices. This relationship is attributable to the relative importance of non-agricultural forces operating in the Limestone Valley market. Tracts transferred in the Limestone Valley were about one-half as large as those in the Black Belt and one-third as large as those in the Wiregrass. Community water lines were present on 41 percent of the Limestone Valley parcels while 3 and 12 percent of Wiregrass and Black Belt parcels had water lines. Although most tracts were purchased for home and farming uses, over one-fourth of the Limestone Valley transactions and almost one-fifth of the Black Belt and Wiregrass sales were purchased for speculation or development. Fifty-four percent of the Limestone Valley, 47% of the Wiregrass and 38% of

the Black Belt parcels were held by the seller for 5 years or less. Houses were present on 28% of the Limestone Valley tracts and 19 and 28% of the Wiregrass and Black Belt tracts. However, houses and other improvements contributed much more to real estate value in the Limestone Valley. After adjusting real estate values for improvements and appreciation using the State average rates, bare land values were \$750 per acre in the Limestone Valley, \$420 per acre in the Wiregrass and \$450 per acre in the Black Belt.

KEYS TO U.S. DOMESTIC VICIOUS CIRCLE PROBLEMS

Heather J. Slemmer. Dept. of Economics. Marian F. Chastain. Dept. of Nutrition and Foods. E. D. Chastain. Dept. of Economics. Auburn Univ., Auburn, AL 36830.

Vicious circle problems are generally recognized relative to newly emerging economies. These problems can also be identified in the U.S. domestic economy. Understanding the nature of such problems and of alternative solutions has great current implications in terms of the role of and costs to government and of the welfare of the people. Knowledge exists that may be helpful in meeting the needs of vicious circle problems. Leadership and effective communication are required. Turning to government handouts and charity may alleviate the situation but, to the contrary, may aggravate the condition. The orientation in this analysis is one of focusing on the productivity of resources and enhancing that productivity.

AN INPUT MODEL FOR ASSAYING AGRICULTURAL IMPACT OF GENERAL DEVELOPMENT PROGRAMS

R. O. Woodward and H. A. Henderson. Div. of Ag. Dev., TVA, Muscle Shoals, AL 35660.

This report describes a model that can be used to evaluate the agricultural potential of land considered for irreversible conversion to other uses such as industry or business. The impact on local communities of converting prime land is stressed. Five elements that have universal application in evaluating the agricultural potential and their economic concomitants are built into the model. They are: indigenous soils, farm sales and economic activity, economic multipliers, land use patterns, and income potential. An example of applying the model to a real situation is given. The need for a universal approach to evaluating the loss of more than 4,000 acres of prime land per day to nonagriculture has never been greater. We are losing 170 acres of farmland per hour yet gaining 360 more mouths to feed. Some believe population will outpace food supply by the year 2000 if proper steps are not taken. This model supplies some positive evaluative criteria that could affect the race between the stork and the plow. Rural people are not well represented among those who make development decisions. So, agricultural information must be extremely relevant, timely, well documented, and well presented if it is to have any impact on the decisions affecting them and their land.

SCIENCE EDUCATION

INTRODUCING ELEMENTARY DIMENSIONAL ANALYSIS INTO MIDDLE SCHOOL SCIENCE

Ernest D. Riggsby and Dutchie S. Riggsby. School of Education, Columbus Col., Columbus, GA 31907.

This project involved: writing a syllabus, selecting pilot classes, performing necessary preliminary tasks, and carrying through the teaching, testing, and experimenting. Early encounters indicated that the students (sixth, seventh, and eighth graders) had passable skills in number concepts and could perform above marginal levels in the basic arithmetic operations. Prerequisite work in the addition of negative, integral exponents, and the general concept of the function of exponents was accomplished prior to the study of dimensional analysis, except for discussions of the general nature of dimensions. The scope of the use of the topic was limited to the qualities: mass, time, length. Near the end of the unit, the students were led to the use of *units* into which various measurements of the basic qualities could be expressed and to the dimensional antecedents of those units. Two salient results obtained: (1) statistically significant results favored the use of dimensional analysis as either prerequisites or corequisites for the study of physical science, and (2) the meticulous efforts utilized in the work with dimensional analysis had divided results. Many students reflected improved motivation and problem solving strategy: a few were negatively affected.

SOCIAL SCIENCES

SOME ASPECTS OF MOBILE IN 1858

Kenneth R. Wesson. Dept. of History, Univ. of Ala., University, AL 35486.

Alabama's port city of Mobile has always been intriguing. Economically, socially, and culturally Mobile was at its height in the late antebellum period, as was the South generally, and especially during the year 1858. Early in the year Mobile became stabilized financially, and attracted more commercial interests and fewer agricultural ones. Due to these factors the majority of the city's free and slave population thrived on the flourishing cotton trade. The labor force was dominated by Negroes and foreigners, the latter constituting 63 per cent of all foreign born in Alabama in 1858. Mobilians prided themselves in the maintenance of their public school system and in the general adherence to the religious awakening which was sweeping the South in the late 1850's. Much concern also centered around transportation and communication to and from the city, and the citizens were ever aware of the progress of their railroad, steamliner, telegraph connections, and newspapers. A lofty social life thrived, in 1858, with many entertainments such as theatre, lectures, fine arts, sports, and musicals available. Despite the occurrence of many crimes, fires, and a yellow fever

Abstracts

epidemic, the tourist and commercial trades continued to gain. As 1858 closed the citizens of Mobile had every reason to hold optimistic views concerning their city's continued prosperity and bright tomorrows.

TUDOR-HAPSBURG RELATIONS 1525-1535

Carol A. Morse. Dept. of History, Auburn Univ., Auburn, AL 36830.

A long tradition of mutual interests stood behind Anglo-Spanish relations in the first years of the sixteenth century. Not only did the two countries share a common anti-French sentiment, but commercial intercourse, royal marriage, and a hatred for heretics and infidels as well. However, when the Spanish monarch, Charles I, became Charles V of the Holy Roman Empire in 1519, tremendous strains were placed upon diplomatic ties with King Henry VIII of England. Charles' possession of Spain, Flanders, and the Empire seriously threatened the new European concept of a balance of power. Francis I of France was the main obstacle to Charles' domination of Europe. England, though far less wealthy or powerful, held the true balance. Hoping to tilt the scales in their favor, both Charles and Francis sought alliances with Henry. Diplomacy was intense throughout the 1525-1535 period and was further complicated by the English break with the Church of Rome, the second in a series of wars between France and the Empire, and the threats of Lutherans in the Empire and Turks to the East. Considering these factors, it becomes evident that the Tudor-Hapsburg relationship was significantly altered in the ten year period.

BELL FACTORY: EARLY PRIDE OF HUNTSVILLE

Cecelia Jean Thorn. Huntsville-Madison Co. Public Library, Huntsville, AL 35804.

With the influx of cotton planters in the early part of the nineteenth century, the Tennessee Valley region of Alabama witnessed unparalleled economic growth. Into this fertile frontier came entrepreneurs who capitalized on the region's new found wealth by establishing cotton textile mills. One such enterprise was the Bell Factory, incorporated in 1832. Located ten miles northeast of Huntsville on the Flint River, the Bell Factory manufactured coarse cloth and cotton bagging in its early days and later produced woolens, sheetings, ginghams and plaids until its closing in 1885. It is a remarkable example of frontier entrepreneurship and shall take its place in Alabama's heritage as the state's first successful cotton textile mill.

THE LITERARY IMAGE OF THE FAR WEST IN THE EARLY NINETEENTH CENTURY

Marsha Kass Marks. Dept. of History, A. & M. Univ., Normal, AL 35762.

The popular literary image of the far West, presented in novels of the first half of the nineteenth century, was an Eastern one. Sedulous followers as well as shapers of popular concepts and cultural attitudes,

the novelists showed to their Eastern readers a thrilling but acceptable picture of their far Western frontier. It was a region with good scenery and bad Indians, where exciting adventures might occur to the hero and heroine. The average member of the mid-nineteenth-century Eastern reading public thus saw the far West not through a window, but in a mirror.

MOBILE'S GREAT HURRICANE OF 1819

Jack D. L. Holmes. Univ. of Ala. in Birmingham, Birmingham, AL 35294.

On Tuesday afternoon, July 27, 1819, a "small but intense" hurricane struck Mobile Bay. Two long-time residents of the Mississippi Gulf coast, Dr. A. P. Merrill and J. C. Moret, described the storm's fury, which was considered among the most destructive recorded to that time. From Pensacola to New Orleans every vessel was driven from the sea. The entire coast was covered with fragments of houses, bodies of human beings and the carcasses of cattle. Soldiers camped forty miles north of Bay St. Louis felt the powerful gale and a tree fell upon Dr. Merrill, the surgeon of the men sent to build a military road connecting New Orleans with Tennessee. For about four hours the hurricane raced up Mobile Bay, which acted as a funnel, and the eye passed over Mobile about midnight. Turtles and alligators were washed up on the streets downtown and one large brig was stranded on Dauphin Street. The schooner *Thomas Shields* was capsized at Bay St. Louis with all hands lost. Another U.S. schooner *Firebrand* lost all on board when the storm blew her from near Pass Christian ashore on the western end of Cat Island near the mouth of the Mississippi. While of small size, the intensity of the 1819 hurricane rates it among the most severe to strike the Middle Gulf coast between 1815 and 1870, according to David M. Ludlum, a noted authority.

THE SECOND PHASE OF SPANISH EXPLORATION AND CONQUEST IN
THE UPPER GULF OF MEXICO, 1512-1561

Henry S. Marks. Educational Consultant, Huntsville, AL 35801. Div. of Social Sciences, Northeast Ala. St. Jun. Col., Rainsville, AL 35986.

It has long been the contention of historians of Gulf history that this region has generally been overlooked in surveys of United States history. In particular the period of Spanish exploration and settlement has been almost ignored. Yet there is no scarcity of information about this period--even in English. As an example, this paper utilizes only sources in English while its purpose is to present the history of the area from what is today Vera Cruz, Mexico, to Key West, Florida, usually referred to during the period from 1512 to 1561 as La Florida. A number of notable achievements can be credited to Spain in the upper Gulf during this period. The Spanish successes and failures in this region provided invaluable experience and lessons for later explorers and colonizers of all nations. The much later success of European colonizations on the North American continent rested upon a framework of Spanish accomplishment and failure in the upper Gulf of Mexico from 1512 to 1561.

THE BATTLE OF CHICKAMAUGA

Roger C. Linton. Huntsville, AL 35802.

For two days in September, 1863, one of the greatest battles of American history was fought in the North Georgia valley of Chickamauga Creek. In a vine-strewn wilderness, largely uncharted, where coordination in battle was difficult, if not impossible, the outcome hinged on a tactical maneuver ranked with the outstanding military feats of the Civil War. Chickamauga, from an old Cherokee legend, means "River of Death," a prophetically appropriate name for this battle of Union and Confederate armies struggling for the prize of Chattanooga, the key rail and communications center of the Deep South, at that time. Highlights of the campaign strategy and battlefield tactics will be presented in the context of interpreting the present-day format of the Chickamauga National Military Park.

SOCIAL DETERMINANTS OF ATTITUDES TOWARD PREMARITAL SEX

Kim Von Kaenel and William F. J. Morgan. Univ. of S. Ala., Mobile, AL 36609.

Several hypotheses concerning factors which may have an effect on a person's attitudes toward premarital sex are dealt with in this paper. A review of the literature on the subject reveals a number of influencing factors. Included in this paper are religion, race, sex, three measures of social class (occupational prestige, education, and total family income), and the intensity with which one practices his or her religion. Data analyzed were obtained from the Codebook for the Spring 1975 General Social Survey put out by the National Opinion Research Center at the University of Chicago. Computer analysis was done using SPSS (Statistical Package for the Social Sciences). Cross-tabulations with chi-square and gamma statistics, along with Pearson Correlations were utilized. Findings show that of the social class measures, only the educational measure appears to be a good indicator of attitudes toward premarital sex. Results also show that sex, race, and religion, as well as religious intensity are good predictors. Tables are included at the end so that the reader can see the results.

HEALTH SCIENCES

PURIFICATION AND PROPERTIES OF HEPARIN N-SULFATE SULFATASE

Jon T. Conary, Jerry Thompson, and Lennart Rodén. Lab. of Med. Genetics, Dept. of Biochemistry, and Diabetes Reserach and Training Center, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Degradation of heparin and heparin sulfate in the course of mammalian metabolism is achieved through the action of several lysosomal enzymes. An important step in this process is the removal of N-sulfate groups, which is effected by heparin N-sulfate sulfatase (sulfamidase). This

enzyme, which is deficient in patients with the Sanfilippo A syndrome, has previously been partially purified from normal human urine by Kresse and Nuefeld (J. Biol. Chem. (1972) 247, 2164). In the present investigation, the sulfatase has been extensively purified from bovine testis, and some of its properties have been determined. After homogenization of the tissue and 3 cycles of freezing and thawing, insoluble material was removed by centrifugation, and the enzyme was precipitated with ammonium sulfate between 20 and 40% saturation. Further purification was accomplished by chromatography on Concanavalin A-Sepharose, Sephacryl S-200, Cibacron Blue-Sepharose and CM-cellulose, yielding 12,700-fold purification over the initial homogenate. In this procedure, the highest purification factor (104-fold) was observed for the Con A-Sepharose step. Chromatography on Cibacron Blue-Sepharose yielded an insignificant increase in specific activity, however, this step was particularly valuable, since it removed two other sulfatases and several glycosidases. On SDS-PAGE, the most highly purified preparation yielded one strongly staining band and seven minor bands. A preliminary estimate of molecular weight, obtained in the course of chromatography on Sephacryl S-200, gave a value of 110,000, which is close to the molecular weight of 114,000 reported for the enzyme from human urine. (Supported by NIH Grants DE-02670, HL-11310 and NIH GRS RR05300 and RR05349.)

IDENTIFICATION OF IMMUNE COMPONENTS WHICH AUGMENT CHEMOTHERAPY OF HERPES SIMPLEX VIRUS INFECTIONS

William B. Davis, M. Wettermark, John E. Oakes, H. H. Hornbeak, and John A. Taylor. Dept. of Microbiology, Univ. of S. Ala., Mobile, AL 36609.

The antiviral drugs 5-ethyl-2'-deoxyuridine (5-EDU) and adenine arabinoside (Ara-A) were shown to prevent a fatal encephalitis in mice following subcutaneous infection with 1×10^6 pfu of herpes simplex virus type 2 (HSV-2). Levels of 500 mg/kg/day of 5-EDU provided a 40% survival rate. A 70% survival rate was observed for animals treated with 500 mg/kg/day of Ara-A. In both experimental groups HSV-2 infected mice not receiving drug had a 100% mortality. In order to determine the specific immune components necessary for the successful antiviral chemotherapy in normal mice, animals were specifically depleted of a T-cell response by treatment with mouse antithymocyte serum (ATS) for three days prior to infection. No protection was provided by 5-EDU or Ara-A in the ATS treated mice against subcutaneous HSV-2 infection. Thus, despite successful 5-EDU and Ara-A systemic therapy in normal animals an intact host immune response is required in order to have an optimal effect with either compound. These studies suggest that T-cells may have a central role in that regard.

QUANTITATION OF IMMATURE T-LYMPHOCYTES

Michael R. Sharpe, Herschel P. Bentley, Jr., and Raymond D. A. Peterson. Dept. of Pediatrics, Univ. of S. Ala., Mobile, AL 36617.

The characterization of T-lymphocyte on the basis of the temperature sensitivity of the E-rosette assay is described in patients with Acute Lymphocytic Leukemia (ALL) and compared to that of normal peripheral blood lymphocytes (PBL) and thymocytes. Thymus tissue from nine children less than 10 years old was studied following sternotomy for cardiovascular surgery. Total Thymus T-lymphocytes were enumerated by rosette formation with sheep erythrocytes after incubation at 4°C and values of $88.4 \pm 3.5\%$ were obtained. Immature Thymus T-lymphocytes were determined by a similar E-rosette technique with incubation at 37°C and values of $81.1 \pm 8.4\%$ resulted. These techniques used to quantitate PBL's from normal laboratory volunteers yielded values of $65.2 \pm 7.5\%$ for 4°C or total T-cells and $10.8 \pm 6.3\%$ for 37°C or Immature T-cells. Lymphocytes from the peripheral blood of two children at the onset of ALL yielded average values of 78% for total T-cells and 55% for immature T-cells resembling Thymus tissue with a majority of immature T-lymphocytes. Quantitation of the peripheral lymphocytes from two other children who had similar clinical presentations with ALL showed an average of 12% total T-cells and 1% Immature T-cells. It is seen that patients with similar clinical presentations of one disease entity can be separated by those rosetting methods into an E-rosette positive immature ALL and an ALL with mature primarily E-rosette negative lymphoid cells.

SEROTONIN LOCALIZATION BY FLUORESCENT TECHNIQUES IN TISSUES OF NORMOTENSIVE AND HYPERTENSIVE RATS

Richard Ross Rebert and Stan Greenberg. Dept. of Pharmacology, Col. of Medicine, Univ. of S. Ala., Mobile, AL 36688.

Eight normotensive and eight hypertensive rats were studied to determine the quantitative localization of serotonin in lungs; mesentery, mesenteric vessels and thoracic aorta. The tissues show widespread distribution of bright yellow fluorescence in cells which have the characteristics of mast cells. In the lung, macrophages are distinguished from the fluorescing mast cells by their size and also their tan-brown non-fluorescence. The mast cells appear in larger numbers under the serosa and along blood vessels in the hypertensive compared with the normotensive rats. The same is true in the mesentery and along mesenteric vessels. The difference in number is more apparent when a comparison is made for the presence of "mast cell chains" which appear more numerous in the mesentery along small vessels. The thoracic aorta does not show greatly enhanced numbers of mast cells compared with the other tissues. A striking feature is the presence in the hypertensive animals of mast cells in the parenchyma of the lung rather than in the serosa and blood vessels. Five additional normotensive rats and five additional hypertensive rats were treated with paraChlorophenylalanine (pCPA) twenty-four hours prior to sacrifice. These animals served as a control to verify fluorescence was that of serotonin. The fluorescence found in the untreated animals is not found in the treated animals.

Abstracts

Serotonin is demonstrated to be present in greater quantity due to the presence of more cells, presumably all mast cells, in hypertensive rats in the tissues examined. The abolishment of serotonin by pCPA suggests that the accumulation of that metabolite in the untreated animals is serotonin.

EFFECTS OF 2-SELENOURACILS ON IODIDE METABOLISM

James L. Thomas and Raymond H. Lindsay. V.A. Hospital and UAB Med. Cen., Birmingham, AL 35294.

Selenium analogs of several goitrogenic thioureylene compounds were synthesized and their antithyroidal activities were determined. Selenourea, 2-selenouracil, 6-methyl-2-selenouracil, and 6-propyl-2-selenouracil were compared with the appropriate sulfur compound in the same experiment. All of the selenium analogs were potent inhibitors of thyroid peroxidase activity in bovine serum albumin iodination assays. The concentration of each selenium compound which produced 50% inhibition of peroxidase activity was not statistically different from that of its sulfur analog. Selenourea also inhibited iodide uptake and iodide organification in rat thyroids *in vivo* with the concentration producing 50% inhibition (ED₅₀) being comparable to that of thiourea. The other selenium compounds failed to produce detectable *in vivo* antithyroid activity at concentrations ten times the ED₅₀ of the appropriate sulfur analog. These results indicate that replacing the sulfur in thioureylene antithyroid drugs with selenium yields compounds which are potent thyroid peroxidase inhibitors and are apparently inhibitors of thyroid function *in vivo*. The inability of 2-selenouracil, 6-methyl-2-selenouracil and 6-propyl-2-selenouracil to inhibit thyroid function *in vivo* may be related to their metabolism or extensive protein binding.

MULTIPLE FUNCTIONS AND PROPERTIES OF VITAMIN C

Emmett B. Carmichael. Prof. Emeritus of Biochemistry, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The English Navy discovered that the juice of limes and lemons could protect against scurvy. Scurvy was produced experimentally in guinea pigs in 1907 on a diet of oats and bran. Hopkins in 1912 reported that foods contain essential substances and Funk named them vitamins. King isolated Vit. C. (ascorbic acid) in 1932. Vit. C. reduces arthritic pain in one's fingers. Pauling, 1970, reported that Vit. C. could prevent and cure common colds, but there is little evidence to support his hypothesis. Radiation response to cervical carcinoma of the uterus was higher following Vit. C. and many terminal cancer patients have lived longer with large doses of Vit. C. Patients with back pain get relief with large doses of Vit. C. Lack of Vit. C. causes emotional stress. Vit. C. content of circulating leukocytes dropped 42% by the 3rd post-operative day and that creates an argument for the use of Vit. C. following surgery. Vit. C. blocks harmful effects of nitrites in meats and helps prevent nitrites from forming carcinogenic nitroso compounds. Vit. C. is an antioxidant which prevents foods from changing color.

Abstracts

Vit. C. is used for producing corrosion resistance on ferrous metal surfaces.

ALTERATIONS OF HEPATIC MICROSOMAL DRUG METABOLISM IN STREPTOZOTOCIN DIABETIC RATS

Thomas D. Donahue and Raymond H. Lindsay. Dept. of Pharmacology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Metabolism of type I and II cytochrome c substrate binding drugs was investigated utilizing male S.D. rats made diabetic by ip injection of Streptozotocin. Key enzymes of the mixed function oxidase system were also investigated to further clarify the mechanism of diabetic drug metabolism. Results (nmoles of compound metabolized/min/mg of microsomal protein) are expressed as % non-diabetic control \pm S.D.

COMPOUND	INSULIN CNTRL	DIABETIC CONTROL			INSULIN Rx
		MILD	MODERATE	SEVERE	
Ethylmorphine	*133 \pm 10	*128 \pm 12	*76 \pm 20	**64 \pm 18	**137 \pm 10
Hexobarbital	102 \pm 11	**36 \pm 6	**59 \pm 10	**65 \pm 10	104 \pm 12
Antipyrine	96 \pm 10	103 \pm 3	101 \pm 3	*90 \pm 2	**163 \pm 11
Chlorpromazine	104 \pm 11	**40 \pm 15	**48 \pm 19	**18 \pm 20	**129 \pm 10
Aniline HCl	*90 \pm 4	106 \pm 4	**147 \pm 12	**164 \pm 10	**64 \pm 12
Amphetamine	**62 \pm 12	90 \pm 3	88 \pm 8	**23 \pm 8	**56 \pm 9
NADPH	*113 \pm 10	*90 \pm 2	*88 \pm 3	*92 \pm 2	106 \pm 3
Cytochrome c	*98 \pm 4	102 \pm 3	99 \pm 3	97 \pm 8	98 \pm 2
Cytochrome P450	**123 \pm 1	99 \pm 3	**69 \pm 2	**56 \pm 1	*113 \pm 2

*P < 0.01 **p < 0.001

Results obtained indicate that diabetes induces a complex alteration of drug metabolism in which qualitative as well as quantitative differences exist between the severity of the diabetic state and drug metabolism. Insulin treatment alters metabolism of some drugs in control and diabetic animals but does not always restore drug metabolism in diabetic animals to control levels.

EFFECTS OF DEPLETION OF FOREBRAIN NOREPINEPHRINE ON PERFORMANCE IN THE BLOCKING PARADIGM

Mary Ann Pelleymounter, Joan F. Lorden, Edward J. Rickert, and Ralph Dawson, Jr. Dept. of Psychology and Neurosciences Prog., Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Fibers of the dorsal noradrenergic bundle (DB) terminate widely in the hippocampus and many of the behavioral effects of hippocampectomy can be duplicated by lesions of the DB. Recent studies have shown that hippocampectomy produces a blocking effect, which appears to be due to the inability of the hippocampectomized rat to properly encode stimuli. The purpose of the present study was to investigate whether similar results could be obtained by selective neurochemical deafferentation of the hippocampus. Rats with 6-hydroxydopamine lesions of the DB or 5,7-dihydroxytryptamine lesions of the midbrain raphe nuclei were compared to sham-operated controls in Kamin's two-stage blocking paradigm. All

Abstracts

rats were conditioned to suppress operant conditioning in the presence of a light or tone that predicted foot shock prior to conditioning with a compound cue (light and tone). When sham or raphe lesion groups were tested for response suppression in the presence of the redundant element from the compound cue, suppression was blocked. Rats with DB lesions failed to show the blocking effect and suppressed their responses in the presence of the redundant cue. Fluorometric assays of hippocampal norepinephrine (NE) and serotonin (5-HT) indicated that DB lesions reduced mean hippocampal NE by 83% and 5-HT by 3% in comparison to sham-operated controls. Rats with raphe lesions showed a 9% depletion of NE and a 78% depletion of 5-HT. The results suggest that the performance of hippocampectomized rats in the blocking paradigm may be accounted for by a loss of NE. (Supported by NSF Grant BNS 77-15251 to JFL and UAB Faculty Research Grant to EJR.)

REGIONAL VULNERABILITY OF THE BRAIN TO ISCHEMIA

Frank W. Marcoux. Neurosciences Prog., Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Twenty unanesthetized macaque monkeys were subjected to middle cerebral artery (MCA) occlusion. Local cerebral blood flow (CBF) was measured from electrode sites in cortical and subcortical gray and white matter within the ischemic area by hydrogen clearance. Histological observations at sites having undergone a similar degree of ischemia were compared in an attempt to determine the more vulnerable tissue. During MCA occlusion of 2-3 hours the CBF threshold for infarction appears equal for all tissues examined. That is, when CBF was reduced to a level of about 12cc/100g/min for 2-3 hours infarction always occurred in gray as well as in white matter. During 1.5 hours of ischemia, however, gray matter areas seem to be more vulnerable to ischemia than do white matter areas. When CBF fell below 8cc/100g/min for 1.5 hours gray matter, but not white matter, died. Recent observations suggest that the neostriatum is particularly vulnerable to ischemia. Relatively mild ischemia (CBF as high as 15cc/100g/min) of 1-1.75 hours duration in these areas has led to sub-total infarction. Here it appears that glial cells survive the insult while neurons do not. These preliminary results suggest both that gray matter is more susceptible to ischemia than white matter and that basal ganglia structures are particularly vulnerable if the ischemic insult is reversed after 1.5 hours. (This work supported in part by NIH Grant NS08802.)

EFFECTS OF 2-DEOXYGLUCOSE ON FOOD INTAKE IN GENETICALLY OBESE MICE

Anita Caudle and Joan F. Lorden. Dept. of Psychology and Neurosciences Prog., Univ. of Ala. in Birmingham, Birmingham, AL 35294.

C57BL6/KS-*dbdb* mice are obese, hyperphagic, and hyperglycemic. Recent evidence suggests central nervous system involvement in this syndrome. Hypothalamic norepinephrine levels (NE) are elevated in *dbdb* mice in comparison with levels in lean littermates and the experimental depletion of central NE causes a significant reduction in body weight

and blood glucose in the *dbdb* mouse. In order to further test the functional integrity of central NE neurons in the *dbdb*, we have examined the response of this mutant to a glucoprivic challenge induced by the injection of 2-deoxyglucose (2-DG). This antimetabolic glucose analog inhibits glycolysis and deprives cells of glucose. In response to this challenge, normal animals increase their food intake. This feeding effect has been shown to depend on NE function. In the present study, 15 lean female mice (either *db+/+m* or *+m/+m*) and 13 obese mice (*db+/db+*) of the same age and sex were housed in single cages and given water *ad lib*. Food was available for 6h/day. Both food and mice were weighed daily and spillage was carefully collected. Obese mice ate significantly more than the lean mice; however, only the lean mice increased their food intake in response to the injection (400 mg/kg, sc) of 2-DG. Equivalent volumes of physiological saline were injected for comparison on control days. When the mice were returned to *ad lib* food, intake in both groups doubled. This suggests that the differential response to 2-DG was not the result of differential deprivation conditions. These data provide additional support for the idea that there is an alteration in NE function in the *dbdb* mouse. (Supported by NINCDS Grant NS 14755-01.)

ON THE CHOICE OF FLUID FOR THE HYDRATION OF FOOTBALL PLAYERS
DURING EARLY FALL PRACTICE IN ALABAMA

W. D. Myers and K. T. Francis. Div. of Physical Therapy, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The effects of administration of a popular glucose-electrolyte (ESJ) solution using 3 different regimes of administration was investigated in 20 players of a local high school football team. Environmental conditions at the time of the experiment were 90°F and 60% RH. The length of practice was 2 hours. Regimen 1 consisted of one "drink" break, 1 hour into practice at which time the players consumed the ES *ad libitum*. Regimen 2 consisted of the administration of 4 ounces of ES every 15 minutes without a specified "drink" break. Regimen 3 consisted of administration of 8 ounces of ES every 15 minutes without a specified "drink" break. ES consumption with regimen 1 was 0.808 liters; ES consumption with regimen 2 was 0.96 liters and 1.92 liters with regimen 3. Even with this fluid consumption, this acute period of exercise resulted in a net weight loss of approximately 3 kg in each of the groups. This acute deficit of fluid volume was reflected in all three groups as a decrease in physical work capacity. Pre practice/post practice work capacity decreased 31% in subjects following regimen 1, and 25% and 23% in subjects following regimen 2 and 3 respectively. Assuming a Na⁺ sweat concentration of 40 mEq/liter and a K⁺ concentration of 5 mEq/liter, the total quantity of Na⁺ and K⁺ lost from the body during the 2 hours of exercise remained approximately the same with each of the 3 replacement regimens. In terms of the difference between the average electrolyte intake and electrolyte lost, regimen 3 replaced significantly more of the lost electrolytes than did the other two regimens.

EFFECTS OF ANXIETY ON EMG BIOFEEDBACK MUSCLE RELAXATION TRAINING
AND GENERALIZATION OF TRAINING EFFECTS

S. J. Dixon. Div. of Physical Therapy, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

This study was undertaken to determine if the personality trait of anxiety has an effect on electromyogram (EMG) biofeedback muscle relaxation training and the generalization of training effects from a trained muscle to an untrained one. Subjects were selected by their scores on the State-Trait Anxiety Inventory by Spielberger, Gorsuch and Luchene. Ten high anxiety subjects and ten low anxiety subjects were chosen to participate. Each group was divided into five experimental subjects and five control subjects. The subjects underwent four sessions spaced at two to three day intervals. Experimental subjects experienced actual EMG biofeedback training while the controls heard a pseudosignal, unrelated to actual muscle tension. The biceps brachi of the dominant arm was the muscle designated as the training muscle. Electromyogram signals were monitored from both the dominant and non-dominant biceps in order to determine decrease in muscle activity. The data gained was used to test the following four hypothesis: 1) EMG biofeedback will facilitate relaxation in a trained muscle; 2) A generalization effect from a trained muscle to an untrained one will occur; 3) high anxiety subjects will reduce muscle tension by a greater amount than low anxiety subjects; 4) the degree of generalization will differ between high anxiety and low anxiety patients.

IDIOPATHIC SCOLIOSIS AND THE MENSTRUAL ONSET--ARE THEY RELATED

Louise E. Johnson. Div. of Physical Therapy, Univ. of Ala., in Birmingham, Birmingham, AL 35294.

The purpose of this study was to determine if the onset of menarche differs between girls with and without scoliotic curves and whether the onset of menarche differs between girls with different curve sites. A sample of females with idiopathic scoliosis was gathered from an orthopedist's file and from a school screening program. Onset of menarche was determined retrospectively from phone calls made to mothers and/or girls if they were over 11 years old. Name, site of curve, degree of curve first recorded, birthdate, and age at menarche were recorded. Curves were measured by the Cobb method. Girls in the final sample (n = 127) included those with thoracic, thoracolumbar, and double major curves. Thirty-three of the 127 had not yet begun menstruating. The mean age of menarche was 12.82 years for double major (n = 31), 11.70 years for thoracic (n = 18) and 12.05 years for throacolumbar (n = 45) curves. A significant difference (95 per cent confident) was found between the means of double major and thoracic, and double major and thoracolumbar, but not between thoracolumbar and thoracic curves. The mean age of menarche for females with double major curves is older and the thoracic and thoracolumbar means are younger than the national average. The range, mean and distribution of the age menarche for each curve site showed the range to be greatest for thoracolumbar (9.59), then double major (5.58), and least for thoracic (3.75).

COMPLIANCE BEHAVIOR IN HYPERTENSIVE PATIENTS

Kathleen G. Andreoli. Univ. of Ala. School of Nursing, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The purpose of this study was to determine if there were differences in self-concept and health beliefs in hypertensive patients who practiced compliance and who practiced noncompliance regarding prescribed therapy. The sample consisted of 71 male patients enrolled in a hypertension clinic in a Veteran's Administration Medical Center for a minimum of one and one-half years prior to the study, who experienced blood pressure control one year prior to the initiation of the study, were on antihypertensive drug therapy during the year prior to the study, kept their clinic appointments during the study, were able to read and follow directions on the study instruments correctly, experienced no physical or emotional stress at the time of the study, and signed the informed consent. These patients were categorized as compliers or noncompliers based upon a one year clinical record of their diastolic blood pressure levels and the clinic nurses' interpretation of their status of compliance over this time. The findings revealed a statistically significant incidence of noncompliance in blacks as compared to whites. There was no statistically significant difference in the scores on the Tennessee Self Concept Scale between compliant and noncompliant patients, and both groups obtained scores within normal limits. In the scores on the Health Beliefs Questionnaire there was no statistically significant difference between compliant and noncompliant patients, and both groups obtained scores which approximated the best possible scores for all health belief categories.

THE EFFECTS OF MONOAMINE UPTAKE INHIBITORS ON
CONDITIONED TASTE AVERSIONS

William B. Nunn and Joan F. Lorden. Dept. of Psychology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Reductions in brain serotonin (5HT) levels have been shown to increase the suppressive effects of pairing a novel taste cue with injections of lithium chloride (LiCl). Pretreatment with 5-hydroxytryptophan increases brain 5HT levels and decreases the aversion to the novel taste cue. Fluoxetine HCl has been shown to be a specific 5HT uptake blocker. This experiment examined the effects of 5HT uptake inhibition on taste aversion learning. Rats acclimated to a 23h water deprivation schedule were injected ip with 10 mg/kg of fluoxetine or with an equivalent volume of .9% saline 1 h prior to a 10 min presentation of 50 ml of a 5% sucrose solution. Immediately after the sucrose presentation, all rats were injected ip with 12 ml/kg of .15 M LiCl. The rats were given a 3 day recovery period and were then tested with a 10 min sucrose presentation. A second training trial was performed 4 days later. Subsequently all rats were tested with 10 min sucrose presentations on alternate days for 5 extinction trials. The rats that received the fluoxetine pretreatment showed a decrease in sucrose intake on the days of the fluoxetine injections. Larger decreases in sucrose intake were observed in the saline-pretreated rats following the LiCl injections. On all

Abstracts

extinction trials, the saline pretreated rats drank significantly less sucrose than did the fluoxetine-pretreated rats. No significant difference in 10 min water intake between the two groups was observed on any day. Both groups of rats showed significant decreases in water intake on the days immediately following the LiCl injections. These data suggest that the fluoxetine-pretreated rats experienced the noxious effect of LiCl injections but did not associate it with the taste cue. (Supported by NSF Grant BNS 77-15251.)

THE EFFECTS OF VARIOUS NEUTRAL AMINO ACIDS ON d-AMPHETAMINE INDUCED CIRCLING IN RATS WITH SUBSTANTIA-NIGRAL LESIONS

Issam H. Humaideh and John M. Beaton. Neurosciences Prog. and Dept. of Psychiatry, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

It has been shown that following unilateral lesions of the substantia nigra, rats will turn to the side of the lesion when they are given amphetamine. One of the ways in which amphetamine acts is by releasing pre-synaptic stores of dopamine and norepinephrine. We have previously shown that L-valine is capable of blocking this amphetamine induced circling. The present study was carried out to study the effects of L-valine, D-valine and L-leucine on rats with unilateral substantia nigral lesions and administered various doses of amphetamine or apomorphine. Adult, male Long-Evans rats were anesthetized and placed in a rat stereotaxic and electrolytically lesioned in the right substantia nigra. After recovering from surgery the rats were tested with amphetamine at 2 or 4 mg/kg and apomorphine at 1 or 2 mg/kg, singly or 30 min. after 250 mg/kg of one of the amino acids. The number of turns, to the left or right, made during one minute were recorded at 0, 15, 30, 45 and 60 minutes after the administration of the drug. L-valine and L-leucine markedly decreased the amphetamine induced circling but had no effect on apomorphine induced circling. D-valine had no effect on the turning induced by either drug. The mode of action of the suppression is thought to be via the lowering of brain tyrosine levels by competitive inhibition of the transport system for tyrosine into brain.

BEHAVIORAL EFFECTS OF POSTNATAL INJECTIONS OF MONOSODIUM GLUTAMATE IN MICE

Ralph R. Dawson, Jr. and Joan F. Lorden. Dept. of Psychology and Neurosciences Prog., Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Mice treated during infancy with monosodium glutamate (MSG) suffer neuronal degeneration and exhibit both obesity and neuroendocrine abnormalities as adults. The purpose of this investigation was to evaluate the behavioral and physiological effects of MSG treatment. Male and female albino mice of the CF-1 strain born in the laboratory served as subjects. MSG injections were given from Days 4-14 postnatally. Dose was increased from 2.8 mg/g to 4.8 mg/g over this period. Controls were injected with an equivalent volume of 0.9% saline. MSG-treated mice showed significant increases in body weight and adiposity as measured by the Lee Index. MSG-treated mice were also found to have significantly

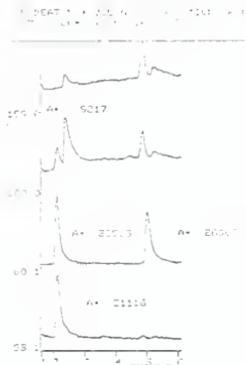
Abstracts

decreased naso-anal length. Measures of daily food intake indicated that MSG-treated mice ate significantly less food than saline-injected controls. Food intake was also measured after 24h of deprivation. The increase in food intake following this regulatory challenge was significantly smaller in the MSG-treated mice than in saline-injected controls. Animals were studied under two housing conditions, single or group-caged. Many characteristics of the MSG syndrome appeared only in the group-housed animals. When maintained in the single cages, body weight declined. Activity levels, while significantly lower in group-housed MSG animals, increased to normal levels in singly-caged MSG animals. Body temperature was also affected by housing condition. Group-housed MSG-treated animals had significantly lower body temperature in comparison to group-housed, saline-injected controls and singly-housed MSG and saline-treated animals. (Supported by NINCDS Grant 14755-01.)

A DETERMINATION OF N,N-DIMETHYLTRYPTAMINE IN HUMAN CEREBROSPINAL FLUID (CSF) AND RAT BRAIN USING GAS CHROMATOGRAPHY-MASS SPECTROMETRY

John M. Beaton. Neurosciences Prog., Univ. of Ala. in Birmingham, Birmingham, AL 35294. Joachim P. Gardemann. Univ. of Cologne, Cologne, West Germany.

N,N-Dimethyltryptamine (DMT) has been postulated as the psychotoxin involved in schizophrenia. The present study was carried out to determine the levels of DMT in rat brain and in human intraventricular fluid (IVF) and CSF. Purified synaptic vesicles were prepared from the brains of groups of three or six rats. The vesicles were then extracted with methylene chloride and the extract derivatized with heptafluorobutryl imidazole (HFBI). For the human study 5 ml of IVF or CSF were extracted with methylene chloride and derivatized with HFBI. Samples of the derivatized extracts were then analyzed on a GC-MS. DMT was found to occur in rat brain and exogenously administered deuterated DMT was found in the brain synaptosomes of rats sacrificed thirty minutes after intraperitoneal administration. DMT also occurred in the human IVF and CSF, as can be seen in the hard copy print of an IVF sample. DMT has a retention time of 2.2 min. and a mass fragment of 58.1 (with an area of 31,116 units). This sample contained approximately 545 pg/ μ l, a very high level of DMT. Although DMT was shown to be present in human samples, no relationship was found between the occurrence of DMT and the illness schizophrenia.



A RURAL HEALTH CARE PROJECT FOR MIGRANTS IN THE
SAND MOUNTAIN AREA OF NORTHEAST ALABAMA

Gayle Becker and Eloise Clark. Univ. of Ala. School of Nursing, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Although approximately 4,000 migrant workers reside in Alabama during the spring and summer of each year, very little attention has been paid to their health needs. For this reason, a rural health project was initiated in the summer of 1978. In an effort to identify health problems and meet some of the needs of this particular group, two small nursing clinics were established in the Rainsville and Henagar communities. The initial plans were to provide health screening and health education, but immediate treatment and referrals became the first priority. Daily visits to the migrant camps were also necessary for follow-up care and assessment of those without transportation to the clinics. Some of the findings from this project were as follows: 1) There is virtually no statistical data regarding the number of migrants in the state, nor information indicating the nature of their health needs. 2) There is a critical need for all facets of health care for this mobile population. 3) There are numerous opportunities for student learning experiences and faculty enrichment activities in the area of migrant and rural health. 4) A mobile health care unit would be more efficient than a stationary unit in meeting health needs.

COMPETENCY BASED EDUCATION IN THE HEALTH SCIENCES

William B. Shell. School of Pharmacy, Auburn Univ., Auburn, AL 36830.

There have been, in recent years, innovations in educational practice such as educational technologies, systems approaches, and management tools. These innovations combined with the societal pressures of accountability, cost effectiveness and a growing need for personalization in a society thought to be increasingly dehumanizing, have given the impetus for the development of what is known as competency based education (CBE). Competencies (knowledge, skills, behavior) to be demonstrated by the health care professional (HCP) include the following elements and characteristics--derived from explicit conceptions of the HCP's role--so as to make possible assessment of a learner's behavior in relation to specific competencies, and--made public in advance--including feedback elements that constantly update the process.

A LONGITUDINAL EXAMINATION OF FACTORS RELATED TO ADOLESCENT HYPERTENSION

Mary Louise Fleming and Marianne Murdock. Univ. of Ala. School of Nursing, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

A preliminary analysis of the initial data gathering effort in a longitudinal study designed to identify the relationships between school-aged adolescents' demographic, psychographic, and social interaction characteristics and blood pressure levels is reported. The purpose of the research is to attempt to determine if examination of these

characteristics in this group may, over time, suggest possible intervention strategies for the prevention and detection of adult hypertension. One hundred school-aged adolescents (average age sixteen years) were screened for hypertension at a Birmingham area metropolitan high school. On a scale of perceived health status (1 = poor, 10 = excellent), the average health perception was 8.1. The average systolic blood pressure of the respondents was 116.931 mmHG; the average diastolic blood pressure was 70.00 mmHG. Six clinic and/or physician referrals were made as a result of the screening. A preliminary analysis indicates no statistically significant differences between reported "crisis" events in the subjects' lives and average diastolic blood pressures. There were statistically significant correlational relationships between subjects' self-perceptions as measured on a Likert-type scale and average diastolic blood pressures. There were also statistically significant correlational relationships between subjects' actual and ideal self-perception differentials and diastolic blood pressures. A factor analysis of the self-perceptions scales indicated eight actual self-perception types and six ideal self-perception types.

POOR INITIATION OF LACTATION: NURSING DIAGNOSIS AND INTERVENTION

Ellen B. Buckner and Rebecca Sloan. Univ. of Ala. School of Nursing, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Milk production during the phase of initiation of lactation is subject to profound individual variation. Several factors may contribute to poor initiation of lactation if they occur during this time. These include Cesarean-section delivery, postpartum infection, diminished suckling by the baby, maternal age over 25, lack of knowledge of breastfeeding techniques, policies which restrict frequent nursing and the physiological effects that anxiety related to these problems may create. Poor initiation of lactation can be identified when there is an absence of filling or engorgement of breasts after 72 hours after delivery, when the baby loses greater than 5% of birth weight, when the baby voids less than 6 times per day or stools less than 2 times per day in first week. The mother may report difficulty getting the baby to nurse well and nipple soreness may occur from the suckling of an empty breast. Poor initiation of lactation frequently results in mother abandoning breastfeeding and occasionally may result in nutritional deprivation in the child. Nursing intervention has traditionally been directed toward increasing frequency of nursing, increasing fluid intake and providing emotional support. Adjunct nipple stimulation using an electric breast-pump which mimics the suckling of the newborn may be an effective intervention. The case study presented here describes the identification of the diagnosis of poor initiation of lactation and possible intervention. Research is in progress to study the prolactin response to suckling in women with poor initiation of lactation and possible effectiveness of adjunct stimulation in resolving the problem. The study is supported by a University of Alabama in Birmingham Faculty Research Grant.

THE EFFECTS OF AMPHETAMINE AND CAFFEINE ON FLUID VOLUME
INTAKE IN RATS EXHIBITING SCHEDULE-INDUCED POLYDIPSIA

Mark K. Addison and John M. Beaton. Neurosciences Prog. and Depts. of Psychology and Psychiatry, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Food-deprived rats fed pellets of food on an intermittent schedule of reinforcement, with a water bottle available, normally drink shortly after the delivery of each pellet. Under these conditions the rats will drink excessive volumes of fluid. This present study was carried out to examine the effects of 0.5 and 1.0 mg/kg amphetamine and 10 and 20 mg/kg caffeine on rats exhibiting this schedule-induced drinking or polydipsia. Twelve adult male Long-Evans rats were trained on a variable interval 30 sec. schedule of food reinforcement. A water bottle containing either water or a solution of saccharin (0.05% or 0.1%) was available in the experimental chamber. The animals were run daily and session duration was 60 min. The number of bar presses, the number of reinforcements obtained and the volume of fluid consumed were noted daily. Both levels of amphetamine and caffeine decreased the volume of fluid consumed in the experimental chamber. This decrease was compensated for by an increase in home cage water intake. This decrease in fluid intake occurred with drug levels which do not alter fluid intake in water reinforced schedules and also did not alter the number of food reinforcements obtained in this study.

THE EFFECTS OF VARIOUS HORMONES ON THE FLINCH-JUMP TEST IN RATS

C. Leigh Millican, C. Patrick Lane, and John M. Beaton. Neurosciences Prog. and Depts. of Psychology and Psychiatry, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

It has been shown that the administration of adrenocorticotrophic hormone (ACTH) to rats results in the delay of shuttle-box avoidance extinction. It has been suggested that this is because ACTH plays a role in motivational processes. It is hypothesized here that ACTH may lead to an increase in the sensitivity of the animals to pain, thereby delaying the extinction of responses to painful stimuli. In the study reported here, the effects of ACTH (100, 200, 400 and 600 μ g/kg), vasopressin (5, 10 and 20 I.U./kg) and morphine (5.0, 7.5, 10.0 and 12.5 mg/kg) were examined on the flinch-jump response of twelve adult male Long-Evans rats. Saline was injected as a control and drug test sessions were separated by at least three non-test days. Each session consisted of five trials of flinch-jump tests. Each trial consisted of an ascending, followed by a descending, series of 1 sec. foot-shocks delivered at 30 sec. intervals. The levels of shock at which the animals flinched or jumped were averaged over all trials. The data showed that both morphine and vasopressin had little effect upon the flinch threshold but increased the jump threshold in a dose-dependent manner. ACTH on the other hand significantly decreased the flinch threshold but had little effect on the jump threshold. These data indicate that ACTH increases the sensitivity of rats to pain, as measured by the flinch response of the flinch-jump test.

ABSENCE OF ALTERED LIVER β -GALACTOSIDASE IN AGING FISCHER 344 RATS

Roger S. Lane and H. R. Prasanna. Dept. of Biochemistry, Col. of Medicine, Univ. of S. Ala., Mobile, AL 36688.

The occurrence of catalytically incompetent forms of several soluble enzymes in senescent cells of a variety of phylogenetically distant organisms has led to the postulate that the accumulation of aberrant proteins is a universal phenomenon in aging animals. To evaluate this hypothesis, we have searched for possible age-dependent changes of lysosomal β -galactosidase in liver tissue of the male Fischer 344 rat. No significant differences in the level of enzyme activity were observed in liver extracts of young adult (9-12 mo), middle-aged (24 mo) or very old (32-34 mo) animals. Immunotitration analyses of these extracts with monospecific antiserum directed against purified mouse liver enzyme further indicated the absence of abnormal β -galactosidase molecules in aging liver tissue; antibody consumption required to inactivate 50% of a defined amount of active enzyme was the same in all age groups. Heat inactivation studies also support this conclusion; age-related alterations in enzyme thermostability were not demonstrable. Our results, therefore, do not support the view that the cellular accumulation of faulty proteins represents a general manifestation of biological aging.

EXCLUSION OF THE EFFECTS OF DAMAGED ENDS IN THE STUDY
OF ISOLATED CARDIAC MUSCLE MECHANICS

D. N. Reeves, L. L. Hefner, T. C. Donald, and A. A. Walker. Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The mechanical characteristics of the central segment of the isolated papillary muscle were determined with recently developed equipment. Two small, sharpened stainless steel wires, inserted transversely through the muscle, were used to mark the ends of the muscle. Installation of the pins did not effect the performance of the muscle. The distance between the pins along the longitudinal axis of the muscle was servo-controlled by the apparatus to produce isometric and afterloaded isotonic contractions of the segment of the muscle between the pins. The accuracy of the segment length was verified by 35 mm photographs taken during contraction at 100 msec intervals. Segments defined by microspheres applied externally as well as internally correlated well with the segment lengths defined by the pins. Previous evidence (J. W. Krueger and Gerald H. Pollack, J. Physiol, 1975, 251, pp. 627-643) demonstrated that the movement of internal microspheres is closely correlated with sarcomere length, suggesting that relative changes in segment length in our preparation are proportional to changes in sarcomere length. During conventional isometric contractions in which the whole muscle was kept at constant length, segment length was found to shorten as much as 11%. When segment length was prevented from shortening, force was found to increase as much as 50%. In conventional afterloaded contractions the central segment shortened as much as 5% before the muscle as a whole shortened at all. For all muscles, the amount of shortening of the segment at the smallest afterload averaged 27% versus 14% when the whole muscle was measured at the same afterload ($P < .01$).

Abstracts

L_{max} was determined for the whole muscle as the length at which developed force reached a plateau. No evidence was found in any muscle of a plateau of developed force for the segment, no matter how far it was stretched. The results indicate that it is very important to measure the length of the central undamaged segment instead of the whole muscle with its damaged ends.

ENGINEERING

CUBIC SPLINE INTERPOLATION APPLIED TO MISSILE TRAJECTORY GENERATION

Alexander C. Jolly. US Army Missile Research and Dev. Command, Redstone Arsenal, AL 35809.

The application of piecewise cubic spline interpolation techniques to the generation of vehicle trajectories from discrete, widely-separated values of vehicle position as a function of time is described. Various interpolation methods are discussed and the underlying basis of piecewise cubic splines is given, followed by an application of the technique to a particular example. Additionally, the trajectory generation technique is extended to the calculation of vehicle Eulerian angles, including angles of attack for the case of air-supported vehicles.

ON THE BOX-JENKINS METHOD FOR PARAMETER ESTIMATION

G. Bruce Williams, Computer Sciences Corp., Huntsville, AL 35807.

The Box-Jenkins method is applied to the empirical output of a physical filter. The parameters of the Box-Jenkins model are compared to the design specifications of the filter as a measure of the validity of a computer simulation based on the design specification. An additional result of the analysis is an estimate of the actual noise in the system which may be used in the computer simulation for a more realistic simulation.

IBSSU: A NOVEL APPROACH TO PRECISION STABILIZATION

James L. Baumann and Mark D. Dixon. US Army Missile Research and Dev. Command, Redstone Arsenal, AL 35809.

Many situations require long range sensing or surveillance from a dynamic vehicle. Examples include scene recording with electrooptical sensors from a ground vehicle or aircraft. This information when used for surveillance or target acquisition requires high resolution. The resolution requirements necessitate that the sensor be isolated from the vehicle base motions. This is typically accomplished by mounting the sensor on an inertially stabilized platform utilizing feedback control to attenuate the vehicle angular base motion effects on the sensor line-of-sight. Translational base motion also degrades resolution by coupling through platform mass unbalances and by noise introduced into

Abstracts

the platforms motion sensors. Platform bearing friction also acts to degrade the stabilization performance. The Internal Bearing Stabilized Platform (IBSSU) concept significantly reduces both the translational motion and the bearing friction degradation of stabilization performance. The IBSSU utilizes passive translational isolators to reduce the translational disturbance to the platform. These isolators are configured to function "in parallel" with the active control loop and thus eliminate the classic design limitations of isolator mounted stabilized platforms. The IBSSU stabilized platform is supported at its center of gravity by a single spherical ball bearing which reduces the frictional effect. To demonstrate this concept an experimental model was fabricated to empirically demonstrate improved line-of-sight stabilization accuracies. The results demonstrate that accuracy improvements by a factor of 3 to 5 times can be expected with "soft mounted" stabilized gimbal platforms over the conventional techniques.

SIMILARITY MEASURES FOR TIME SERIES DATA

Gary M. Griner. Science Applications, Inc., Huntsville, AL 35805.
Harold L. Pastrick. Guidance & Control Directorate, US Army Missile Research and Dev. Command, Redstone Arsenal, AL 35809.

Confidence in the validity of a simulation is often established by comparing time-dependent output variables with actual data. When data is not available the comparison is sometimes made using the output of a higher fidelity model. What is lacking is an accepted quantitative measure of the degree of similarity. Such a measure could have numerous applications in pattern recognition problems as well. This paper presents several methods for measuring the quantitative similarity of two time series. Methods for testing for simple bias and scale differences are presented and the need for time-aligning the data is stressed. Three higher-order similarity measures are proposed: The correlation coefficient $r = \sigma_{AP} / \sigma_A \sigma_P$; a form of Theils inequality coefficient, $U' = \sigma_E / (\sigma_A + \sigma_P)$; and a covariance coefficient, $2\sigma_{AP} / (\sigma_A^2 + \sigma_P^2)$, where σ_A^2 , σ_P^2 and σ_E^2 are the variance of the two data sets and the variance of the difference between them and σ_{AP} is the covariance. A method of correcting for autocorrelation within the data is discussed. The method, due to Tomek, assigns weights to each data point according to the change in slope at the point. An application is presented using two simulations of a pneumatic missile fin actuator and actual flight data.

KNOWN METALLURGICAL COAL RESOURCES OF ALABAMA

Reynold Q. Shotts. Dept. of Mineral Engg., Univ. of Ala., University, AL 35486.

Estimates of coal resources of Alabama have been made but no separate estimate of coals suitable for metallurgical use is available. As part of a summer 1978 project, 1290 proximate and 340 ultimate published coal analyses were collected and the carbon, fixed carbon (rank), and heating value calculated to the unit coal basis and correlated, largely using ultimate analyses. It was found that rank (expressed as total carbon

Abstracts

or fixed carbon) correlated well with oxygen content and less readily with heating value and with carbon to hydrogen atomic ratio. Certain values ranges also correlated well with geographical location so that they could be used to select areas of metallurgical, borderline metallurgical, and non-metallurgical coals. Using Culbertson's estimated coal resources (1964) as of January 1, 1958 and Shotts' 1971 and 1975 unpublished corrections for 1958-1974 coal production, a rough, first-order estimate was made. The Warrior coalfield has 2.62 billion tons, the Cahaba 0.19, Coosa none, and Plateau 1.3×10^{-3} billion tons of metallurgical coal. Of the borderline coals, 1.3 billion tons are in the Warrior coalfield, 0.57 in the Cahaba, and 12.2×10^{-3} billion tons in the two Warrior smaller coalfields.

THE ENGINEERING OF POLICY DESIGN

John L. Cain. Research Relations, Auburn Univ., Auburn, AL 36830.

Policy design is art and science. It involves structure, management, and communication; hence, an engineering system. The engineering of successful policy design requires both system and human understanding. A policy system is power sensitive. The behavior of a policy system and potential modification must be assessed, in determining the paths of least resistance for successful output or building system resistance for successful defeat, depending upon the desired system response. Criteria for decisions may involve economic, religious, legal, political, social, and technical considerations. Opinions, not facts, generally control, but facts are also important in arriving at value judgments. Engineers and scientists should become more involved in responsible inputs to policy for the public benefit. Questions involving energy policy design, for instance, relate to "What *is* Alabama energy policy? On what principles should policy be based? What design criteria for energy policy are used? Is the design sound? Who decides? How is it implemented?" Intergovernmental relationships and authority are important in policy design--an exercise in fluid mechanics and perpetual motion.

ON THE REALIZATION OF AN OPTIMAL CONTROL LAW FOR A TERMINALLY GUIDED MISSILE--SOFT AND HARD CONSTRAINTS

R. J. York and Peter Sisler. Dept. of Math and C.S., Western Kentucky Univ., Bowling Green, KY 42101. H. L. Pastrick. Guidance and Control Lab, US Army Missile Command, Redstone Arsenal, AL 35809.

The major task was to investigate the implementation into a fully modeled six-degree-of-freedom missile simulation of an optimal control law that was designed to insure a small miss distance and a high attitude angle at impact. The control problem was represented initially by a linear quadratic one with soft constraints on the control u in the form of an integral of u^2 appearing in the cost function. The resulting implementation was extremely sensitive to changes in the initial acquisition geometry. It was felt that the main explanation was the lack of a hard constraint on the control which is in fact the case with the

Abstracts

actual missile. The control problem was reformulated in the context of minimum time and minimum fuel problems with $|u(t)| \leq 1$. The resulting control solution is currently implemented only in a simplified four-step simulation, not in the 6DOF simulation.

PERFORMANCE OF A DYNAMIC GYRO MODEL

Larry R. Murdock. US Army Missile Research and Dev. Command, Huntsvill, AL 35809.

A gimballed two-degree-of-freedom (DOF) attitude gyro whose spin axis is torqued to a point along the line-of-sight (LOS) is a primary guidance device used in today's missile technology. LOS rate for proportional navigation guidance (PNG) is derived from this type of gyro. The guidance law for this scheme is PNG. The missile used here is tail controlled with proportional vane deflection and roll rate controlled. When the missile is near enough to the target to be seen by the guidance device (seeker) which is mounted on the gyroscope, an LOS error (the difference as measured in both yaw and pitch plane of where the seeker is presently pointing and where it should be pointing) is computed. This LOS error torques the gyroscope and eventually drives the missile body vanes which turn the body into line with the pointing seeker. This paper presents the performance of a dynamic gyro modelled for a six-degree-of-freedom digital simulation. Most 6-DOF digital simulations in the past have used primarily the 2-DOF ideal gyro model. Mathematical models and digital simulation results of an idealized gyro model and the dynamical (realistic) model are given. Missile targeting accuracy is described for the two types of 2-DOF gimballed gyros models when implemented in a 6-DOF digital simulation with no changes in airframe, aero, autopilot, and guidance law. The analysis shows that a dynamic gyro model will give a more realistic seeker gyro than an ideal gyro model. More accurate autopilot design and seeker interface design would result in the use of the dynamic gyro model for digital simulations.

ANTHROPOLOGY

NO-TILL AND ARCHAEOLOGICAL SITES

Marjorie W. Gay. Standing Rock, AL 36878.

The methods of no-till farming vary according to such factors as type of soil, topography, land use, the crop, or the attitude of the farmer. Before concluding that an archaeological site will be protected by this method of cultivation, it is important that you investigate what other procedures will be necessary through the years of no-till, such as sub-soiling and land contouring. This paper examines the benefits of no-till and the disadvantages and the potential harm to subsurface cultural deposits. To assure good crops or pasture, the soil must be opened up to great depths periodically.

ANTHROPOLOGY AND THE NEW ARCHAEOLOGY

Harold A. Huscher. Dept. of Anthropology, Univ. of Georgia, Athens, GA 30602.

Anthropology as a general overall coordinating science covers a wide range of the humanistic sciences grouped as Sciences of Man. Anthropology differs from all other sciences in use of the concept of Culture, and for its responsibility for discovering the basic, recurring patterns of culture. Archaeology, documenting events of the unrecorded past, also documents ongoing changes in culture patterns through time. It is this unique role in documenting culture change through time, in setting time frames for the varying aspects of cultural dynamics, that makes archaeological work and results the final arbiters of fact and theory in historical anthropology. Science as a system of inquiry must meet standard canons of science: a high degree of objectivity in dealing with data, and converging multiple lines of evidence in self-correcting systems, so guarding against projection of error. These canons are now being directly violated in all social sciences by polarization into schools arguing inductive vs deductive, indeterminate vs determinate points of departure. The necessity for doubt as the necessary (apodeictic) element in scientific inquiry was recognized four hundred years ago by the father of modern science, who pointed out that those who begin with Truth will end with Doubt, but that those beginning with Doubt may come to Truth. Unchallenged acceptance of a mathematically determined, deterministic culture theory results in the emergence within anthropological community of a generation of persons who have no doubts, people who know, know unconditionally, but often know only one thing and that thing wrong. Inevitable reappraisal is long overdue, a reappraisal leading to return to the scientific method, the Method of Doubt.

A FLINTKNAPPING SITE IN SOUTHEASTERN ALABAMA

David W. Chase. Dept. of Sociology, Auburn Univ. at Montg., Montgomery, AL 36109.

During the spring of 1978, an archeological survey of a proposed recreational park in the City of Dothan, Alabama, resulted in the discovery of a large flint (chert) mining and workshop complex. In view of the certain adverse impact the park's construction would have on this site, arrangements were made to conduct a limited data recovery project there. The result of this work disclosed evidence of settlement activity co-eval with the industrial complex. These data, which involved the recovery of identifiable lithic and ceramic artifacts, aided in the identification of the prehistoric peoples engaged in the industrial process and added new information to a little known aspect of southeastern prehistory.

Abstracts

THE DIACHRONIC DEVELOPMENT OF ENGLISH KINSHIP TERMINOLOGY

Kathleen D. Turner. Dept. of English, Univ. of Ala., University, AL 35486.

English kinship terminology went through several stages before arriving at its present phonological, morphological, and semantic forms. Data from Old and Middle English provide the basis for this analysis of the development of English kinship terminology. A set of semantic equivalency rules is developed to highlight the traces of an Omaha-III type kinship system in Old English. The phonological and morphological development of the terms themselves is also discussed.

APPLIED ANTHROPOLOGY IN WEST BENGAL INDIA

Robert J. Fornaro. Dept. of Anthropology, Univ. of S. Ala., Mobile, AL 36608.

West Bengal is a region of India where tribal peoples are undergoing rapid acculturation. Pushed out of their ancestral forest lands, many tribals turned to pilfering from the agricultural communities to survive. Among these tribals are the Lodhas, a hunting and gathering people who now must adopt agriculture to survive. About 7% of India's 500 million people are tribals. The Government of India through the Tribal Welfare Department has allocated funds to improve the material condition of India's tribals. The Government is committed to integrating tribal peoples into over-all Indian society. In West Bengal the State Government has used anthropologists to develop and implement programs aimed at the "upliftment" of tribal people. Under discussion is the Bidisa Project of P. K. Bhowmick, chairman of the Anthropology Department Calcutta University. Professor Bhowmick has been working among the Lodha for about fifteen years using applied anthropology to improve their condition.

MINUTES

ALABAMA ACADEMY OF SCIENCE
ANNUAL BUSINESS MEETING
University of North Alabama
Florence, Alabama
March 31, 1979

The meeting was called to order at 10:10 a.m. by President William Arendale. The President complimented the Section officers and members for the excellent paper sessions wherein some 228 papers were given. This exceeds the number of papers given in the last three annual meetings.

The President reminded the members of both Senior and Junior Academies that the keynote address would follow the business meeting. He hoped that many would stay and hear Representative Ronnie Flipppo. Representative Flipppo is a member of the Committee on Science and Technology of the United States House of Representatives.

The President then called for the Report of the Counselor to the Alabama Junior Academy of Science, Dr. James Welker.

REPORT OF COUNSELOR TO A.J.A.S.: Jim Welker

The A.J.A.S. treasurer reported a paid membership of 87 science clubs this year. Thirty-five clubs registered as participants in this year's Annual Meeting at Florence, with a total of 250 students and teachers attending the A.J.A.S.-J.S.H.S. Banquet on Thursday night. Speaker for the banquet was Mr. Max Gergel, Director of the Board, Columbia Organic Chemicals Company, Columbia, South Carolina.

New Officers elected for the year 1979-80 are:

President: Danny Herold, Gardendale High School
Vice-President: Fran Cook, Parker High School, Birmingham
Secretary: Kimberly Whitaker, New Hope High School
Treasurer: Theresa Ratliff, Childersburg High School

The following persons received awards:

Henry Walker Memorial Scholarship (\$500)--Tammi Tidwell, Huffman High School.
Student Research Grants--Theresa Ratliff, Childersburg (\$75.00); Danny Herold, Gardendale High School (\$60.00).
AAAS Subscription--Rebecca Stewart, Woodland High School; Theresa Usrey, Childersburg High School.
Outstanding Region--Northeast Region (Mr. Joseph Smith, Counselor).
Outstanding Science Teacher--Mrs. Ruthanne Davis, Ramsey High School, Birmingham.

Minutes

New clubs registered with A.J.A.S. this year are:

Moody Academy of Science Students, Moody High School, Pell City, Alabama
TCA Senior High Science Club, Trinity Christian Academy, Oxford, Alabama
Berry High Science Club, Berry, Alabama
Northside High School Science Club, Northport, Alabama
Escambia County Junior Academy of Science, Atmore, Alabama
Briarwood Christian High School, Birmingham, Alabama
Cherokee County Gifted/Talented Program, Centre, Alabama

J.S.H.S. State Paper Competition winners to participate in the National Symposium to be held at West Point Academy, May 2-5, 1979:

Michael Brummitt--"Some Observed Effects of CO₂ at Varying Relative Humidities on Soy Beans"--Bradshaw High School, Florence, Alabama.

Jeff Caddell--"An Analysis of Impermeability of Spray Paint to Gaseous Radon Through Measurement of Radiation Decay"--Montgomery Academy, Montgomery, Alabama.

Mat Davis--"Summation Formulas for Obtaining the First Five Positive Integral Powers of Non-Negative Integers"--Bradshaw High School, Florence, Alabama.

Robert Hawthorne--"Excavation of Priceville Sand Field"--Decatur High School, Decatur, Alabama.

Bernard Moreland--"Pascal's Recursion"--Glencoe High School, Glencoe, Alabama.

John Piner--"Construction of a Six-Inch Reflector"--Randolph High School, Huntsville, Alabama.

Tammi Tidwell--"Does Paraminobenzoic Acid Absorb Light?"--Huffman High School, Birmingham, Alabama.

Lynda Ward--"Alterations of Bacteriophage Tail Structures by Metal Group Complexes"--Cottonwood High School, Cottonwood, Alabama.

Lynda Ward was selected to read her paper in national competition.

John Piner (Randolph High School) was selected to receive the annual expenses-paid tour of the Bell Laboratories in New Jersey. He will select a teacher from Randolph to accompany him.

Mr. and Mrs. Eugene Osmasta, A.J.A.S. Associate Counselor of Troy State University, will accompany the Alabama students to the J.S.H.S. National Symposium.

In addition to participating in the trips indicated above, the students will be invited to spend two weeks in research activities at the

Minutes

University of Alabama during the first summer session of 1979. It is hoped that this program can be expanded for next year to include other campuses in Alabama.

REPORT OF STATE COORDINATOR OF SCIENCE FAIRS: Mrs. Rosemary Crawford

All Regional Fairs are operating this year. Five have already had their fairs and the remaining two will be held on the week-end of April 5, 1979. Each of the Fairs will send two finalists to the ISEF to be held in San Antonio, Texas May 7-12. Plans are being made by the State Co-ordinator for travel and hotel accommodations for the delegation from Alabama. Adult companions are from the Mobile and Eastern Regions.

REPORT OF GORGAS SCHOLARSHIP FOUNDATION: Leven Hazlegrove

The Gorgas Scholarship Foundation announced today the rankings of the finalists in the 1979 Alabama Science Talent Search. The search was held at the meeting of the Alabama Academy of Science at the University of North Alabama, Florence, Alabama.

The winner of the cash award of \$1,000 tuition grant was:

Lynda Ann Ward, Route One Box 369 A, Cottonwood Alabama 36320, from Cottonwood High School; Teacher: Phyllis E. Walch.

Alternates are:

- 1st Harley Eulin Ryan, Jr., 215 Rita Street RR2, Ohatchee, Alabama 36271, from Westminster High School, Gadsden; Teacher: Mr. Wallace Coker.
- 2nd Duane Henry Pontius, 5342 Dixieland, Birmingham, Alabama 35210, from Shades Valley High School, Homewood; Teacher: Sophia Clifford.
- 3rd David Smith Vernar, 2722 Milford, Florence, Alabama 35630, from Bradshaw High School; Teacher: Mary Nell Gonce.
- 4th Philip Edward Morris, 1372 Juniper Drive, Birmingham, Alabama 35235, from Huffman High School; Teacher: Mr. Robert S. Davis.
- 5th Timothy Frank Bassett, P.O. Box 164, Childersburg, Alabama 35044, from Childersburg High School; Teacher: Priscilla Moody.
- 6th Stephanie Carol Pierce, 117 Dacy Avenue, Jackson, Alabama 36545, from Jackson High School; Teacher: Mr. J. Bruce Hoven.
- 7th Melanie Ann Leopard, 4411 Briarglen Circle, Birmingham, Alabama 35243, from Briarwood Christian High School; Teacher: Dr. Pauline Long.
- 8th Jennings Whitfield Box, 1432 Ferncliff Circle, Birmingham, Alabama 35213, from Briarwood Christian High School; Teacher: Dr. Pauline Long.

Minutes

9th Kuter Kaner, 334 Robinhood Drive, Florence, Alabama 35630, from
H. E. Bradshaw High School; Teacher: Mary Nell Gonce

The rankings were established by a panel of judges consisting of department heads, deans, and professors from many of the leading Universities and Industries in Alabama.

Dr. Leven S. Hazlegrove, Professor and Chairman, Department of Chemistry, Samford University, was Chairman of the Judges Committee.

Winners and alternates in the Gorgas Contests receive offers of tuition scholarships to colleges and universities in Alabama for the study of science. The Gorgas Foundation is named for General William Crawford Gorgas, the Alabama physician who conquered yellow fever in the Panama Canal Zone while serving as Surgeon General in the U.S. Army. The purposes of the Foundation are to promote interest in science and to aid in the education of promising students.

REPORT OF THE SECRETARY: Ken Ottis

Membership Summary:

Members reinstated	-	3
Members deceased	-	2
Members resigned	-	1
Members dropped	-	100
New members	-	50

Total membership 3/15/1979--603 members

Total Senior Academy registration at the 1979 Annual Meeting was 231 members. Pro-ration restriction on travel funds hurt attendance considerably.

Total attendance (A.A.S. and A.J.A.S.) at the Annual Banquet was 266.

The program for the 1979 Annual Meeting presented 228 papers. This is the best we have done in three years.

A tabulation of the papers given at the 1979 Annual Meeting, by Section and Institutional affiliation, follows this report.

PLACE OF MEETING COMMITTEE: Ellen McLaughlin, Chairman

Samford University will host the 1980 Annual Meeting of the Alabama Academy of Science. This has been confirmed by Dr. Ruric Wheeler, vice president of Academic Affairs.

Dr. Urban Diener will contact appropriate officials at Auburn with regards to holding the 1981 meeting there.

Members of the Academy at the University of South Alabama and the University of Alabama, Birmingham have indicated a willingness to work with this committee to arrange future meetings at those institutions.

1979 ANNUAL MEETING A.A.S.: PAPERS BY SECTION AND INSTITUTIONAL AFFILIATION

Institution	Biol. Sci.	Chem.	Geol.	For.	Physics			Soc. Ed.	Soc. Sci.	Health Sci.	Eng.	Anthro.	Totals
					Math.	Ind. Econ.	Sci.						
Auburn Univ., Aub.	22	8	7	3	6	5	4	2	2	1	2	3	63
Univ. AL, Tuscaloosa	-	8	9	2	-	1	-	2	-	-	1	1	24
Univ. AL, Birm.	5	13	3	-	7	-	2	1	22	-	-	-	53
Univ. So. AL	1	-	2	-	-	-	-	-	6	-	-	1	10
Univ. No. AL	4	3	-	1	2	1	-	-	-	-	-	-	11
Auburn Univ., Mont.	-	-	-	-	-	2	-	-	-	-	-	-	2
Univ. AL, Hunts.	2	-	-	-	4	-	-	1	-	-	3	-	10
Jax. State Univ.	3	-	-	4	1	-	-	-	-	-	-	-	8
Univ. of GA	-	-	-	-	-	-	-	-	-	-	-	1	1
Ala. A&M	-	-	-	-	-	1	1	1	-	-	-	-	3
Redstone Arsenal	-	-	-	1	4	-	-	-	-	-	9	-	14
T.V.A.	1	5	-	1	1	5	-	-	-	-	-	-	13
Other Institutions*	4	1	-	2	2	-	3	2	-	-	1	1	16
Totals	42	38	21	14	27	15	10	9	29	16	7	7	228

* Other Institutions: Birm.-Southern, Samford, Snead, Stillman, Troy St., N.E.S.J.C., Industry, Univ. Mich., NASA, Ala. Arch. Soc., Ala. Geo. Survey, Nat. Forests and Ala. Forest. Comm.

Minutes

Minutes

REPORT OF THE RESOLUTIONS COMMITTEE: Hoyt Kaylor

WHEREAS the Alabama Academy of Science has held its 1979 annual meeting at the University of North Alabama, and has enjoyed the hospitality of the University, now therefore,

BE IT RESOLVED that the Academy express its gratitude to Dr. Robert M. Guillot, President of the University, Dr. W. Frank McArthur, Dean of the School of Arts and Sciences, and to the University for hosting this meeting. To Dr. Joseph C. Thomas, Chairman of our local hosts, and to the members of his host committee, Dr. Raymond E. Isbell, Mr. John W. Holland, Jr., Dr. Charles E. Keys, Mr. Frank N. Himmler, Dr. Paul Yokley, and Dr. D. Lee Allison; to the faculty and staff of the University; and to all of the many others who contributed much to the success of this meeting, we, the Academy members, express our appreciation for their efforts on our behalf.

BE IT FURTHER RESOLVED that the Academy express its appreciation to those who retire from leadership this year, and especially to Dr. William F. Arendale, President, and to Dr. Kenneth Ottis, Secretary.

BE IT FURTHER RESOLVED that the Academy expresses its appreciation to Dr. Marvin Schneiderman, and to the Honorable Ronnie Flippo for their presentations to the Academy.

WHEREAS the Academy has lost one of its long-time members through the death of Mrs. Myrtle Alexander, therefore,

BE IT RESOLVED that the Academy extend its sympathy to the family of Mrs. Alexander,

BE IT FURTHER RESOLVED that an appropriate letter together with a copy of this resolution be sent by the Secretary to the family of Mrs. Alexander.

WHEREAS the Academy has lost one of its valued members and a former officer through the untimely death of Dr. George F. Brockman, now therefore,

BE IT RESOLVED that the Academy extend its sympathy to the family of Dr. Brockman,

BE IT FURTHER RESOLVED that an appropriate letter, together with a copy of this resolution, be sent by the Secretary of the Academy to the family of Dr. Brockman.

It is hereby moved by the Committee on Resolutions that the above be accepted and entered in the Minutes of the Academy.

A motion was made and seconded that the above resolutions be entered into the record of the Academy. The motion passed.

Minutes

RESEARCH COMMITTEE: *Jack H. Moore, Chairman*

There was competition at this meeting for Student Research Grants and Student Research Awards.

I. Students Winning Research Grants Were:

1. Steven L. Alexander, University of Alabama, Tuscaloosa, \$185 for the research proposal entitled: White Oak Basketry in the Southeastern United States. Advisor: Dr. Allen R. Maxwell.
2. Michael A. Hoggarth, University of North Alabama, \$200 for the research proposal entitled: A Study of the Distinguishing Characteristics of Two Closely Related Species of Freshwater Mussels in the Genus *Obovaria*. Advisor: Dr. Paul Yokley, Jr.
3. Wallace A. McCord, Auburn University, \$200 for the research proposal entitled: Description of a Flood Delta Thanatocoenose Eutau Formation, Montgomery County, Alabama. Advisor: Dr. Ronald Taylor.

II. Students Winning Research Awards Were:

1. Juan L. Navis, University of Alabama in Birmingham, 1st place, chemistry. Paper title: Synthesis of a 1, 6-diaminoalditol using TBDMS ethers. Advisor: Dr. Donald E. Kiely.
2. Carlton D. Randleman, Samford University, 1st place, biology. Paper title: Inhibitory Effects of Selenium on Induced Rat Ovarian Tumors. Advisor: Dr. Ellen W. McLaughlin.
3. John B. Weed, Auburn University, 1st place, economics. Paper title: Objective Credit Scoring -- An Analysis of Agricultural Borrower Characteristics. Advisor: Dr. William E. Hardy, Jr.

First place winners will receive a \$50 cash award and a certificate.

- ### III. Three students submitted requests for Travel Grants before the February 1 deadline and received grants based upon the round-trip mileage at 15 cents per mile.

NOMINATING COMMITTEE: *Reuben Boozer, Chairman*

The following nominations were presented:

President	-	Jack Moore, UNA
First Vice President	-	Geraldine Emerson, UAB
Second Vice President	-	Kenneth Ottis, Auburn
Secretary	-	John Pritchett, Auburn

Minutes

A.J.A.S. Counselor - Faye Wells, UNA
A.A.A.S. Counselor - H. A. Henderson, TVA

Board of Trustees:

William J. Barrett, Southern Reserach Inst.
Emmett Carmichael, University Ala., Birmingham
G. O. Spencer, Troy State Univ.
Robert Gudauskas, Auburn

Vice Chairman, Section:

Biological Science - Sam Campbell, UAH
Chemistry - Ray Isbell, UNA
Social Sciences - Earl McGee, UNA
Health Sciences - Walter Wilborn, USA
Engineering - John Cain, Auburn
Anthropology - Reed Stowe, USA

There being no nominations from the floor a motion was made that the above slate of officers be elected by unanimous consent. The motion was seconded and passed.

The Annual Business Meeting was adjourned at 11:15 a.m.

NOTES

Notes

**THE JOURNAL
OF THE
ALABAMA ACADEMY
OF SCIENCE**

**AFFILIATED WITH THE
AMERICAN ASSOCIATION FOR THE
ADVANCEMENT OF SCIENCE**

VOLUME 50

OCTOBER, 1979

NO. 4

EDITOR:

W. H. Mason, General Biology, Auburn University, Auburn, AL 36830

ARCHIVIST:

R. G. Eaves, Department of History, Auburn University, Auburn AL 36830

EDITORIAL BOARD:

R. T. Gudauskas, Chairman, Department of Botany and Microbiology, Auburn University, Auburn, AL 36830

E. A. Curl, Department of Botany and Microbiology, Auburn University, Auburn, AL 36830

W. W. Paulder, Department of Chemistry, University of Alabama, University, AL 35486

ADVISORY BOARD:

W. L. Alford, Auburn University

Walker H. Land, Jr., IBM

Charles Baugh, Univ. South Alabama

H. S. Marks, N. E. St. Jr. Col.

G. F. Brockman, Univ. Ala., B'ham

M. Miller, Univ. South Alabama

R. J. Fornaro, Univ. South Alabama

W. W. Paudler, UA, Tuscaloosa

A. Wayne Lacy, Auburn Univ., Mtgy.

Dan Whitson, Decatur

E. M. Wilson, Univ. South Alabama

The Journal is the official publication of the Alabama Academy of Science, and is indexed in Biological Abstracts, Chemical Abstracts, America: History and Life, and Historical Abstracts.

Publication and Subscription Policies

Submission of Manuscripts. Submit all manuscripts and pertinent correspondence to the EDITOR. Each manuscript will receive two simultaneous reviews. For style details, follow Instruction to Authors, J. Ala. Acad. Sci. 50:96-97, 1979.

Reprints: Requests for reprints must be addressed to authors.

Subscriptions and Journal Exchanges: Address all correspondence to the CHAIRMAN OF THE EDITORIAL BOARD.

Advertising, News Releases: Advertisements and news releases will not be published in the Journal.

CONTENTS

ARTICLES

On the Economics of Simulation Donald W. Sutherlin and Harold L. Pastrick	186
Diplomatic Relations Between England and the Dominions of Charles I and V, 1525-1535 Carol A. Morse	195
A Look at Alternative Product Distribution Systems William E. Hardy, Jr. and Vayden L. Murphy, Jr.	211
Status of the Coyote and Red Wolf in Alabama Thomas W. French and Julian L. Dusi	220
Fungi of Alabama. VIII. Some Higher Species of the Auburn Area D. J. Gray and G. Morgan-Jones	225
INDEX	226

ON THE ECONOMICS OF SIMULATION¹

Donald W. Sutherlin and Harold L. Pastrick
Technology Laboratory
US Army Missile Research and Development Command
Redstone Arsenal, AL 35809

INTRODUCTION

Perhaps one of the most widespread concepts in today's society is that of simulation. A large percentage of the general public has a feeling for simulation, be it only in terms of the simulated space flight (TV animation) that appears on the screen when the spacecraft becomes inaccessible to the TV cameras. However, simulation is not just a modern day tool. Perhaps Adam and Eve were primarily concerned with "read world" situations, but Cain, their eldest child, must have played with mud pies or rode a stick horse thereby earning him the title of the world's first simulator [1]. Throughout the millenia simulation has proven an invaluable tool when the real thing was not available for experimentation either for physical or economic reasons.

An article by E. R. Lewis [2] brings us rapidly from prehistoric stick horses and mud pies to the works of some early modelers such as A. Borelli who used a rope configuration to study muscle contraction. The familiar Bohr atom model is a useful and much used simulation. Most earlier physical models served their intended purpose, but they were, in general, cumbersome and left something to be desired in terms of convenience and flexibility. Only with the development of another technology, computers and their synergistic combination, could simulation come into its own as a scientifically oriented tool. In fact, this widespread influence has caused many simulation experts to create their own pet definition of simulation.

Before discussing the economic benefits of simulation, it is imperative to precisely define the term "simulation." This term has, in general, included modeling and the use of models to study physical systems. Simulation was proclaimed in *Simulation* in 1963 [3] to mean "the act of representing some aspects of the real world by numbers of symbols which may be easily manipulated to facilitate their study." A definition of the authors' for simulation that is oriented toward their more specific application is:

Simulation for missiles is the development and utilization of software and/or hardware models to aid in the comprehensive evaluation of present and future missile system concepts.

¹Manuscript received 25 October 1978; accepted 10 January 1979.

On the Economics of Simulation

BROAD APPLICATIONS OF SIMULATION

The form for mathematical models and thus the computer models for simulation are identical for many different types of problems. Thus, only the names and values of various variables need be changed to solve a completely different problem. This allows for the transfer of simulation technology not only within a discipline but also across disciplinary lines. A casual survey of today's literature quickly shows that simulation technology has indeed spread to many fields of study. For example, books have been written concerning simulation in the areas of urban studies, transportation, social science, politics, marketing, law enforcement, economics, and behavioral science [4-6]. In addition, there have been numerous papers, masters' theses, and doctoral dissertations on the subject of simulation [7-9].

Unquestionably the original impetus to the massive permeation of simulation technology into our society was via the aerospace industry. The period following World War II was marked by an accelerated trend toward automation where computers, themselves a high expression of automation, played an important role in process control and industrial automation. Much of the activity was sparked by wartime efforts in development of sophisticated staff planning on a massive scale [10]. The extension from computer programmed staff planning, such as evidenced in models of linear programming and game theory within the military structure, to modeling of specific aerospace systems evolved along with the widespread influx of high speed analog and digital computers into the nation's industrial capital equipment inventory.

The degree to which simulation of aerospace and defense oriented systems is funded is an elusive figure. Even qualitative assessments are not easy to conjure since the simulation activity varies widely from phase to phase within the program. For example, in the conception phase of a new system it is not unusual for a small team of engineers to spend nearly all of their time developing a good mathematical and physical description, or "model," of the system. Subsequently, this model is used to obtain sensitivities to critical parametric changes. As the system evolves through Advanced Development (AD) and Engineering Development (ED) and more emphasis is placed on feasibility demonstration, greater effort is placed on simulation as additional subsystems are critically defined--yet the simulation effort in AD and ED may fall to a relatively small percentage of the total program. As many as several dozen engineers may be involved in this iterative process while even a larger number are involved in prototype development, laboratory testing, and, finally, flight testing the system.

Simulation costs across the spectrum of DOD's \$126.0 billion FY79 Total Obligational Authority (TOA) is not insignificant [11]. Those systems still in the Research, Development, Test and Engineering cycle will use a large share of the (TOA) budget of \$11.0 billion for some form of simulation activity. It is impossible to say how much money is spent on simulation, but if it is only a small percentage of the total budget, this would represent tens of millions of dollars.

There is intense activity in the simulation area across the entire Army mission. The US Army Electronics Research and Development Command is highly involved in the simulation support of the Utility Tactical Transport Aircraft System, the Heavy Lift Helicopter, and the Advanced Attack Helicopter. Simulations in the areas of climatology, nutrition, and organic structure at the Natick Laboratories are at the other end of the spectrum. Of course, the mission of the US Army Missile Command (MICOM) is replete with simulation activity of weapons for air defense, tactical antitank, tube-launched, gun-launched, rail-launched and helicopter-launched munitions. There are fundamental simulation studies on laser spectra, laser propagation, holography, meteorology, climatology, propulsion, structures, fluidics, sensors, and nuclear effects as well as many others [12]. It is probably reasonable to suggest that if a system is conceivable, it can be modeled and simulated. Often, the simulation of alternative systems (or models) leads to the best system (or most acceptable model).

US ARMY MISSILE RESEARCH AND DEVELOPMENT COMMAND
TECHNOLOGY LABORATORY SIMULATION ACTIVITY

Simulation within the Technology Laboratory at MICOM has several important roles. It can help the analyst, planner, or engineer try his missile designs privately before committing more resources to the project or it can help him refine a design originally based on a trial and error basis before the system reaches the prototype stage.

However, there is another often neglected use, that is the simulation's role as a demonstrator. A simulation can show the client, be he a Program Manager or Laboratory Director (who after all is paying for the design) just how the proposed design will work. Also, it often prompts the client to ask awkward questions about the system that the engineer would rather have left unanswered at the early design stage since he, too, is undergoing a learning process.

Simulation's role as a demonstrator within the Laboratory is taken further. It is well known that to develop and run a simulation of a complex weapon system, it must be described completely and unambiguously (modeled). This is always among the engineer's first tasks. He must take the list of requirements, which may very well be inconsistent, define physical and technical constraints within which he must work, and specify a solution. This cognitive process forces interaction between the engineer and his client and builds the cooperation required for a successful design attempt.

Concept verification and performance evaluation are closely tied together, differing primarily only in the timeframe of the R&D cycle. The Laboratories' contribution to the success of the Copperhead Projectile (CLGP) development is well documented [14, 15]. The CLGP concept was established and verified well before the first contracts were awarded to design the flight hardware. Follow-on simulation using hardware-in-the-loop (HWIL) techniques saved an estimated \$1.5 million dollars in R&D funds by simulating the flights in the Laboratory prior to flying the actual hardware on the test range. The certification of flight

On the Economics of Simulation

worthiness via the HWIL simulation was a critical milestone in the evaluation cycle in judging the CLGP performance [16].

Preliminary estimates for cost savings using HWIL simulations have been made for the STINGER, PATRIOT, and SHORADS development programs [17]. The number of live firings which can be eliminated using simulation will depend on the agreed-upon numbers of firings required without simulation. Since these starting point estimates have been changing rapidly, no absolute savings estimates can be made. The approach taken here is to generate a point estimate of potential savings based on Program Manager FY74 firing plans. The overriding criterion in the estimation process is those firings would be eliminated for which an equal or greater quantity of data could be provided by the simulator. The estimated number of firings employing simulation and the appropriate cost savings are shown in Table 1. This table shows that a potential savings of approximately \$150 million resulted by using simulation in the test and development programs of these three missile systems. Although only three systems are evaluated, comparable savings could be realized for other Army missile systems.

Table 1. Typical estimated cost savings using simulation

Missile	Total Live Firings (1974 Estimates)	Estimated Live Firings Using HWIL Simulation	Approximate Cost (Millions FY76 Dollars)
PATRIOT	141	101	80
ROLAND	224	95	42
STINGER	185	114	25
			<u>147</u>

The benefits of the savings that could be accrued from HWIL simulation cannot be measured totally on the basis of the number of firings eliminated from the firing plan. Additional downstream savings, which cannot be precisely quantified, could result from the more thorough testing under a much wider range of engagement conditions that can be generated by simulation but are impractical to produce on the firing range.

EVOLUTION OF A UNIQUE SIMULATION CONCEPT

Simulation has been in many instances, an art rather than a science. The Advanced Simulation Center (ASC) at MICOM was conceived as a national resource that could "pull it all together" with simulation regarded as a science rather than practiced as an art [18]. The ASC consists of a centrally located hybrid computer complex surrounded peripherally by three effects simulators. The Electro-Optical, Infrared, and Radio Frequency Simulation Systems (EOSS, IRSS, and RFSS, respectively) are capable of spectral bandwidths and physical motions necessary for

the evaluation of a wide variety of spectrally and inertially stimulated guidance systems and components. Under central computer control of the simulators, both open and closed loop real time simulation capability is achieved, thus permitting precise and repeatable measurements of homing system performance characteristics of guidance-homing systems in non-destructive tests. Figures 1 through 4 give an overview of the physical characteristics of the environmental effects simulators as well as the hybrid computer complex.

The ASC was envisioned at its inception in 1968 as a tool that would allow management to make more informed decisions on technology and new material development by filling the then current "test bed gap." It was to be and is a flexible simulation test bed with high fidelity battlefield environmental simulation models that could fill the gap between (a) existing laboratory simulations designed for specific programs and not readily adaptable, (b) low fidelity war gaming models without HWIL capability, and (c) test ranges that were useful only late in the game, after weapon system prototypes could be flown.

Another goal of the ASC, and one which should prove to be of immense value in the years of austere R&D budgets, is the identification of critical technology problems and components with large payoff potential for concentration of limited R&D resources. Experience gained from past and present programs allows one to predict with confidence that simulation is a cost effective tool in the evaluation of new material and weapon system concepts. By identifying and resolving critical issues early in the planning and concept phase of the development process, yields may be maximized. Such early identification shifts development risk into the early phase of the program before major commitments have been made to a specific design approach and thus minimizes the occurrence of "surprises" in the Advanced Development and Engineering Development phases. Use of the ASC's unique capabilities throughout the development phase will significantly reduce life cycle cost, development risk, and schedule slippage. Table 2 shows the projected simulation density in the ASC showing tasks ranging from concept through the production and deployment phase [19].

Today's R&D engineers and managers have challenging roles that are vitally important to the fulfillment of defense as well as societal needs. Simulation can and must play an ever-increasing part of that role.

REFERENCES

1. McLeod, J., "Simulation Today--and Yesterday," *Simulation Today*, Volume 1, 1972.
2. Lewis, E. R., "Some Early Simulations," *Simulation*, February 1967.
3. McLeod, J., "Simulation is WHA-A-AT," *Simulation*, Fall, 1963.
4. Forrester, J. W., *Urban Dynamics*, MIT Press, Cambridge, 1969.

On the Economics of Simulation

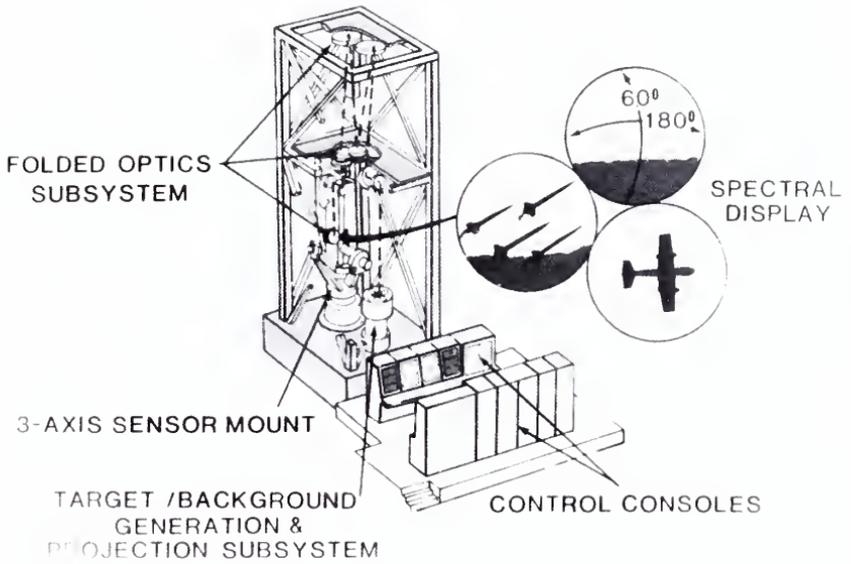


Fig. 1. Infrared Simulation System

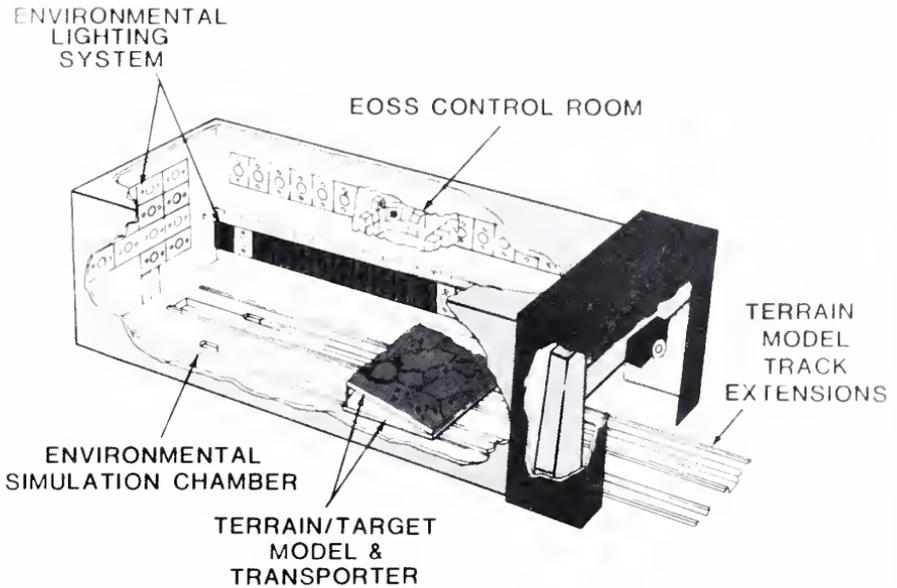


Fig. 2. Electrooptical Simulation System

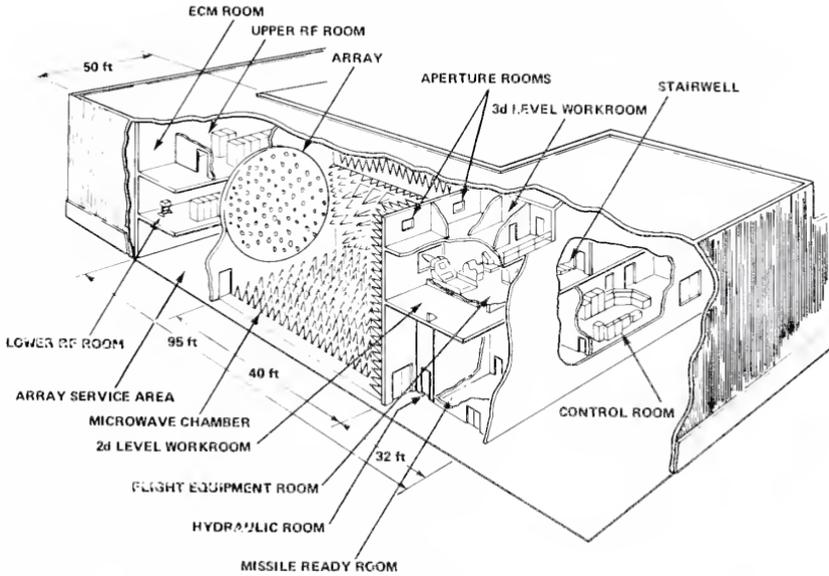


Fig. 3. Radio Frequency Simulation System

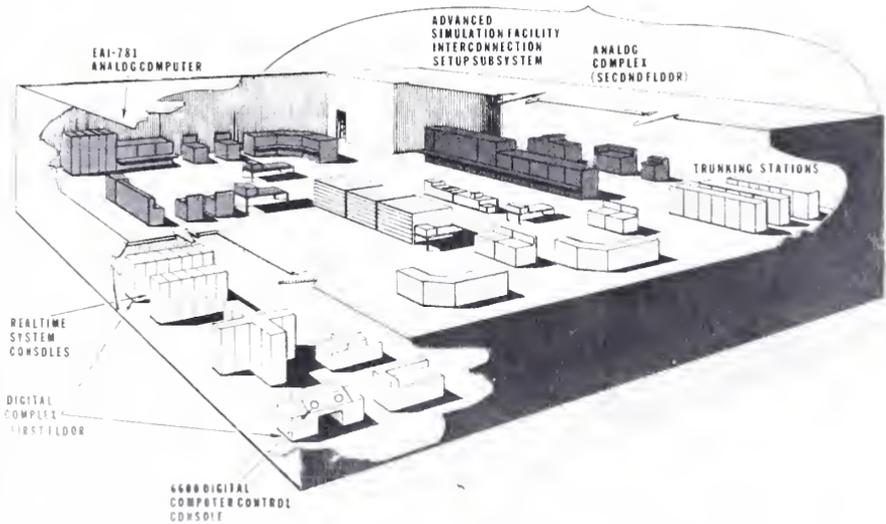


Fig. 4. ASC Hybrid Computing System

Table 2. Density of Projected Simulations Within the Acquisition Cycle

Conceptual Phase	Advanced Development	Engineering Development	Low Rate Initial Production	Production & Deployment
Scene matching area correlator seeker-EOSS	Cannon launched beamrider projectile-EOSS	Advanced TV seeker-EOSS	CLGP/EOSS AN/DAW-1-IRSS	Camouflage studies-EOSS
Defense Mapping Agency area correlation-EOSS	Solid state imaging seeker-EOSS	CLGP/EOSS STINGER-IRSS	PATRIOT ARM/CM-RFSS	DRAGON-IRSS
Active RF seeker-RFSS	Remotely piloted vehicle-EOSS	ROLAND-RFSS	PATRIOT HWIL-RFSS	PATRIOT ARM/CM-RFSS
Low cost air-to-surface missile-EOSS	Advanced TV seeker-EOSS HELLFIRE cockpit studies-EOSS	PATRIOT ARM/CM-RFSS PATRIOT HWIL-RFSS	HAWK-RFSS	Target characteristics simulation-all
	AF low cost DOGFIGHT seeker-IRSS			
	Rosette scan seeker-IRSS			
	Active RF seeker-RFSS			

5. Kresge, D. T. and Roberts, P. O., *Techniques of Transport Planning: Systems Analysis and Simulation Models*, Brookings Institute, Washington, D.C., 1971.
6. Dutton, J. M. and Starbuck, W. H., *Computer Simulation of Human Behavior*, John Wiley, New York, 1971.
7. Sutherlin, D. W., "On an Anti-Radiation Missile Decoy Simulation," *Fifty-Second Annual Alabama Academy of Science*, Auburn, Alabama, April 1975.
8. Sutherlin, D. W. and Kelly, W. C., "A Modern Air Defense System Simulation," *Application of Control Theory to Modern Weapons System Symposium*, China Lake, California, May 1973.
9. Pastrick, H. L., et al., "The Efficacy of Hardware in Validating Hardware-in-the-Loop Simulations," *Summer Computer Simulation Conference*, San Francisco, July 1975.
10. Dantzig, G. B., *Linear Programming and Extensions*, Princeton University Press, Princeton, New Jersey, 1963 (pp. 12-31).
11. ARMY, Vol. 28, No. 3, March 1978, Association of United States Army, Washington, D.C.
12. *US Army Missile Research, Development and Engineering Laboratory Posture Report FY 74*, Report No. RCS AMCDL-101, Redstone Arsenal, Alabama, July 1974.
13. *Computer Aided Missile Synthesis (CAMS) Program*, Martin Marietta Corporation, Final Report No. OR 12, 039, Contract No. DAAH01-72-C-0729, July 1972.
14. Pastrick, H. L., "Terminal Guidance for the Army's 155 MM Cannon Launched Guided Projectile," *Proceedings of the AIAA Guidance and Control Conference*, Stanford, California, August 1972.
15. Pastrick, H. L., York, R. J., and Jolly, A. C., "System Performance Prediction by Modeling Test Data in Digital Simulations," *AIAA Journal of Spacecraft and Rockets*, Vol. II, No. 3, March 1974.
16. Pastrick, H. L., "Testing the Army's CLGP via Hardware-in-the-Loop Simulation," *Proceedings of the Seventh National Guidance Test Symposium*, Holloman Air Force Base, New Mexico, May 1975.
17. Feist, R. J., "Opportunities for Cost Reductions in the Testing of New Missile Systems," *US Army War College Essay*, Carlisle Barracks, Pennsylvania, November 1975.
18. Sutherlin, D. W. and Grider, K. V., "MICOM's Advanced Simulation Center," *Symposium on System Theory*, Auburn, Alabama, March 1975.
19. Grider, K. V. and Longcor, C. L., "Use of Simulation Techniques in Test and Evaluation," *Presentation to DDR&E*, Washington, D.C., November 1975.

DIPLOMATIC RELATIONS BETWEEN ENGLAND AND
THE DOMINIONS OF CHARLES I AND V
1525-1535¹

Carol A. Morse
Department of History
Auburn University
Auburn, AL 36830

The concept of a balance of power was new to sixteenth century Europe, yet it was the inevitable outgrowth of the struggle for domination between the Hapsburgs of Spain and the Holy Roman Empire and the French house of Valois. Within this atmosphere of political tension, England, far less significant than France or the Empire in wealth or military prowess, assumed a new position of importance in European diplomacy. Thus, Hapsburg and Valois turned to the throne of England in search of the support that could assure victory over one another.¹

Relations between England and the Empire in the 1520s and 1530s were significantly different than they had been in the latter part of the fifteenth century. While in the former period the two powers had enjoyed an alliance of mutual interests with few complications, by 1525, England had much to fear from the Hapsburgs. In the person of Charles I and V were consolidated not only the throne of Spain, inherited from his maternal grandparents, but also the Hapsburg dominions, inherited from his paternal grandmother. Furthermore, Charles had been elected Holy Roman emperor in 1519.² In the face of such overwhelming power, Henry VIII's only chance was to try to ally England with France, yet this solution in itself presented some serious difficulties. The English people as a whole were strongly anti-French, a feeling which was rooted in the Hundred Years' War. On the other hand, England was solidly bound to the Hapsburgs through marriage, commerce, defense against the Turks, and a common desire the Lutheran heresy be destroyed. English desires to secure independence on the European political scene, to avoid wars or territorial acquisitions by other states potentially detrimental to English interests, to create dynastic stability, and yet to maintain the long standing beneficial ties with the Hapsburgs were conflicting. All were integral parts of a policy to promote national interests and security and, collectively, constituted the prime motivating force in Anglo-Imperial diplomacy from 1525-1535.³ It will be observed that the means employed to achieve these ends by Henry and his minister, Cardinal Thomas Wolsey, were often at odds and resulted in a period of diplomatic inconsistency.

¹Manuscript received 11 April 1979; accepted 9 August 1979.

As the modern system of diplomacy began to emerge, ministers of state played an increasingly important role in European politics. The new system of negotiations developed as much from theoretical questions such as the balance of power as it did from practical necessity. For whatever reasons, the permanent foreign ambassador had become an integral fixture on the diplomatic scene by the reigns of Charles V and Henry VIII.⁴ Imperial relations with England during the 1525-1535 period were conducted, for the most part, by two ambassadors. The first of these, Don Iñigo de Mendoza, was a count of Spanish origin, abbot of Santa Maria de la Vid in Castile, and bishop of Coria.⁵ He was succeeded in 1529 by Eustace Chapuys, of whom little is known other than that he was of Swiss origin and was educated in Flanders.⁶ English representations to the court of Charles V were less regular. Although in 1531 England had no official representative there, relations were maintained by Dr. Augustine de Augustinis, a physician.⁷ He was replaced by a more official ambassador in the person of Thomas Eliot, formerly in the service of Henry's minister, Cardinal Wolsey.⁸ Finally, Thomas Cranmer, who later became the first protestant Archbishop of Canterbury, was made Henry's sole ambassador to Charles.⁹ Also representing England in Imperial dominions, though in a very different capacity, was Henry's agent for commercial relations with the Netherlands, Stephen Vaughan.¹⁰

These foreign ambassadors were often used in the negotiation of dynastic marriages. The 1492 Treaty of Medina del Campo included a marriage between Arthur Prince of Wales, son of Henry VII, and Catherine Princess of Aragon, daughter of Ferdinand and Isabella.¹¹ Twenty-two years later, England negotiated a marriage between Louis XII of France and Mary Tudor, sister of Henry VIII. The alliance with France was the culmination of a near revolution in English diplomatic policy, yet it was typical of a trend increasingly evident in the face of growing Hapsburg strength.¹² Despite a history of Hapsburg-Valois territorial disputes over Milan, Naples, Burgundy, Artois, Flanders, Roussillon, Cerdagne, and Navarre, the European balance appeared relatively stable in 1516. In that year, following the death of Ferdinand of Spain and the accession of his grandson Charles, France and Spain signed the Treaty of Noyon in which Charles agreed to marry Louise, daughter of the new French monarch, Francis.¹³ The precarious balance had been made secure and remained so until the Spanish monarch's election as Holy Roman Emperor Charles V in 1519 upset it again. Through inheritance and acquisition, Charles had amassed the greatest empire of the early modern period. From this position, he began to assert the concept of a united Christendom and, by this act, threaten the emerging nation-states of France and England.¹⁴

English national self interest now became manifest in a search for a balance of power, or universal peace as it was called in the sixteenth century. The conception and attempted execution of this policy must be attributed to Cardinal Wolsey. Largely due to Wolsey's efforts, Charles became, in 1520, the first Holy Roman emperor to visit England since his predecessor Sigismund made the journey in 1416. Also in 1520, similar negotiations took place between Henry and Francis in the famous meeting on the Field of Cloth of Gold. The peace ended when, on 25 August 1521, England unaccountably made a secret alliance with Charles against France.

England and the Dominions of Charles I and V

This raises the question of who promulgated the action. Wolsey's earlier position indicates a conflict between the cardinal and king. It is possible this departure from established policy was initiated by Henry. French counteraction was swift and inevitable and the ensuing Hapsburg-Valois wars lasted off and on for thirty-eight years. French military efforts in the first four years of the conflict were remarkably successful. However, on 24 February 1525, Francis was defeated and captured at Pavia. Europe was at Charles' feet and England had helped to put it there.¹⁵

Francis was a prisoner, but his mother, Louise of Savoy, took over with great courage. She sent a mission to London to point out to Wolsey the possible consequences of French ruin and total Hapsburg domination. The mission resulted in the Anglo-French defensive alliance concluded at More on 30 August 1525. The importance of the English alliance to both Hapsburg and Valois was made quite evident in the relatively generous terms by which Francis' release was negotiated.¹⁶ By the Franco-Imperial Treaty of Madrid, Francis renounced claims to Burgundy and Flanders, and promised to leave his sons, Henry and Francis, in Madrid as hostages.¹⁷ Charles wrote to Henry concerning the treaty, stating his sole desire was to see a universal peace in the Christian world and he wanted England to be a part of that peace.¹⁸

Charles' words of peace were not enough to convince the English and French that Hapsburg domination was not a threat, and in 1526 Francis resumed hostilities against the emperor and Henry contemplated accepting the position of leader in a league being formed against Charles. The league, later to be called the League of Cognac, was to include Pope Clement VII, France, Venice, Milan, and Florence, and formed on the pretexts of freeing the duke of Milan and getting the Imperial forces out of Italy. In truth, it was an attempt on Francis' part to avoid fulfilling his part of the Treaty of Madrid.¹⁹ Despite his earlier partiality toward France, Wolsey feared an open break with the emperor and convinced Henry not to accept the position as protector of the league.²⁰ Charles, too, sought to influence Henry's decision on the league, advising him the motivations of the French and Italians were those of ambition and not of peace.²¹ Responding to Charles and Wolsey, the English monarch determined a better course of action would be to negotiate a general peace without delay, not waiting until all the princes could assemble, but immediately empowering their ambassadors to act in their behalf.²² Charles promptly granted such powers to his English ambassador, Don Íñigo de Mendoza.

When Mendoza arrived in England in 1527, he found the negotiations of a general European peace to be a difficult task. In an interview with Wolsey early that year, the cardinal told Mendoza he wanted a truce first, and only then would England be ready to negotiate a permanent peace. Mendoza rejected the plan, stating his goal was to arrange for the permanent settlement necessary to prevent the outbreak of another war.²³ Henry protested to Charles that Mendoza's mission was going to be fruitless unless he used the authority entrusted to him. He further accused the emperor of trying to negotiate with France and the pope, exclusive of English representations.²⁴ Despite his misgivings concerning

the emperor's actions and intentions, Henry continued to press for a general peace negotiated in England. He requested Charles to grant Mendoza new powers to negotiate a speedy peace and to include the power to abrogate all former treaties so the whole issue might be settled in England.²⁵

Finally tiring of delays and inaction on the part of the Imperial representative in England, Henry concluded an alliance with the French on 30 April 1527. The agreement stated neither party would give assistance to any enemy of the other, England would renounce all claim to French territories, and France would pay England fifty-thousand crowns annually.²⁶

Charles' anxiety increased as he saw the web of alliance between France, England, and the pope drawing ever closer about him. Using his position in Italy, the emperor ordered Pope Clement VII to withdraw from the League of Cognac, but the pontiff refused. The pope's defiance came at the most inopportune moment, for Imperial troops in Italy were long overdue to be paid and were becoming increasingly restive. Sensing the coming danger, the Imperial commander sent two warnings to Clement, but they went unheeded. On 6 May, the troops entered Rome and began eight days of looting and destruction. Finally, on 7 June, Clement surrendered not to be released until the following November.²⁷ Despite Charles' denial of any actual responsibility for the sack of Rome, the incident so horrified Europeans, anti-Imperial alliances such as that between France and England became even stronger.²⁸

As the outcry over the events of the spring subsided, the major European powers returned to discussions and plans for a general peace. One of the most significant plans was submitted in July 1527 by the French ambassador, Gabriel de Grammont, bishop of Tarbes. He proposed Francis' sons be returned upon payment of a certain sum to the emperor, Francis suspend his pretensions to Naples during Charles' lifetime, and Francesco Sforza be restored to his duchy in Milan which Charles held at the time. English representatives urged Charles to consider the proposals or suggest an alternative plan, but were disappointed.²⁹ Despite rejection of the bishop's proposals, French and English agents continued to suggest plans for peace to the emperor throughout 1528. Seeing all propositions met with similar refusal, Henry appealed to Charles' desire to see a united Christian world, adding it was more important than ever since the Turkish threat was becoming more menacing.³⁰

English sentiments became increasingly anti-Imperial throughout 1527 and 1528. Mendoza related to Charles that a play had been given in which the Spaniards were portrayed as barbarians and the emperor as a tyrant.³¹ Charles, realizing he was making no progress at the English court, made a declaration in December 1527 in which he stated all his efforts to obtain a general peace had been subverted and he had decided to keep the Duchy of Milan.³² Then, as if to backtrack and calm the English fury, he advised Mendoza to try to bride Wolsey and foment discord between Henry and Francis.³³

Talk of peace continued, but even as it did, preparations were being made for open confrontation between England and the Hapsburg

Empire. England began preparing a small fleet of warships.³⁴ The inevitable finally became fact when England joined France in a formal declaration of war against the emperor. The import of the traditional Anglo-Imperial alliance was clearly illustrated when Charles made a retaliatory declaration of war on France, but declined to do so in the case of England unless that country actually attacked Hapsburg dominions.³⁵

Then, almost unexpectedly, peace came to Europe in the summer of 1529 as the Treaty of Cambrai was negotiated in August by Francis' mother, Louise of Savoy, and Charles' aunt, Margaret, regent of the Low Countries. In return for two million crowns, Charles renounced his claim to Burgundy and returned Francis' two sons. In addition, Francis renounced his claims to Flanders, Artois, and Italy. A separate peace had been made with the pope in June.³⁶

Joyously hailed in England as the great peace so long sought after, Cambrai proved to be no more than a truce in the continued Hapsburg-Valois struggle. Henry's disappointment was genuine as he said,

I fancied at one time that this Treaty of Cambrai [sic] would be the means of insuring peace and tranquillity to all Christendom. I was mistaken; ambition and lust of power must still be alive in the Emperor's heart, since Alessandria is, I hear, being besieged by his troops.³⁷

Thus disillusioned with the Hapsburgs, the English monarch began once more to engage in military armament and to make friendly overtures toward France. In the winter of 1530-1531, reports were abroad that Henry was building ships, repairing fortresses, and significantly bolstering his arsenals.³⁸ Relations between Charles and Henry had so deteriorated by 1532, the emperor considered plans to depose the reigning Tudor and replace him with James V of Scotland or Henry's own daughter, Mary.³⁹

Rumors of armament, treaty violations, and coming hostilities continued throughout the next two years, but by 1535, Charles had decided war with England was out of the question. Beset by unavoidable conflicts with the French and Turks, the only course of action open to him was to attempt to renew the English alliance with the House of Burgundy.⁴⁰ Charles was soon to learn, however, in all his offers to England, he was outbid by the French. With the death of the duke of Milan in October 1535, the inevitable resumption of war between Hapsburg and Valois became imminent. France realized the importance of English support in the coming conflict and was making offers to Henry that Charles could not or would not match.⁴¹ Henry had not yet made his choice when, in 1536, Francis attacked Milan and Piedmont. Once again the future of the two greatest powers in Europe could be significantly altered by the actions of the English king.

Important as it was, the power struggle between Hapsburg and Valois was not the only issue of Anglo-Imperial diplomacy in the 1525-1535 period. A second issue of great importance was the divorce of Henry

from his wife, Catherine of Aragon. It played a significant part in England's relations with Charles because Catherine was the daughter of Ferdinand and Isabella, and thus the aunt of the Holy Roman emperor. In 1501, Catherine had come to England and married Arthur Prince of Wales. In 1502, however, Arthur died, so Henry VII appealed to Pope Julius II for a dispensation which would allow prince Henry to marry his brother's widow.⁴² Like all monarchs, Henry hoped the marriage would produce a male heir, but this was particularly important in England where the memory of dynastic civil war was one of the not-so-distant past. By 1526, Henry had become very dissatisfied with the marriage since his only child by Catherine was a daughter, Mary. In addition, Catherine was eight years older than Henry and it was doubtful she would bear him any more children.⁴³

Early in 1526, Wolsey seized upon Henry's misgivings concerning his marriage and used them as a part of his anti-Imperial plan. The cardinal's ultimate desire was for Henry to divorce Catherine and marry a French princess, uniting the two countries against Charles. The second part of the plan proved unacceptable to Henry as he became infatuated with and determined to marry Anne Boleyn, a former member of the queen's household.⁴⁴ The emperor made plans to meet Wolsey at the upcoming Council of Cardinals at Avignon, hoping to persuade him not to support the divorce, but his scheme did not succeed. Instead, the cardinals presented an address to Clement implying that, since he had been captured at Rome and was in the emperor's power, they would consider no act of his as valid. This of course, would include any ruling on the divorce, so Wolsey's name was at the head of the list of the signators to the address. Mere words having been so unsuccessful, the emperor now authorized Mendoza to bribe the cardinal with nine-thousand ducats annually, six-thousand ducats every time a bishopric became vacant in the Empire, and a marquise in Milan with a rent of fifteen-thousand ducats a year.⁴⁵ Again, he failed, this time due to the unrelenting pressure Henry was exerting upon Wolsey over the issue.

Charles could not make Wolsey his ally on the divorce question and was advised to choose the alternative--to destroy him. The Imperial councillors at Valladolid reminded the emperor Wolsey had said as long as the pope was Charles' prisoner, he was not to be obeyed. They suggested the cardinal was already making plans to separate the Churches of England and France from Rome. At the same time, Catherine urged Charles to force Clement to revoke Wolsey's legatine powers in England.⁴⁶

By 1527, Henry had become bolder in making known his plans for divorce. In May, Mendoza reported Henry had assembled a number of bishops and lawyers for the purpose of declaring that, due to irregularities in the dispensation, it was illegal.⁴⁷ Upon hearing this, Pope Clement stated he could make no concessions to the king on the issue, beseeching Henry to "consider the ruin which is hanging over me."⁴⁸

Clement succeeded in stalling Henry until 1528 when he empowered Wolsey and Cardinal Lorenzo Campeggio to hear the case in England. Secretly, however, he instructed Campeggio to persuade Henry to give up the divorce.⁴⁹ Charles was so certain the legatine court would never

meet, he assured Catherine nothing would be done to her detriment and the whole case would ultimately be referred to Rome.⁵⁰ Henry continued to press for the meeting of the legatine court in England and Campeggio failed in his secret mission, stating an angel from heaven could not persuade Henry his marriage was legal.⁵¹

Amid increased diplomatic strains between England, the Empire, and the pope, the legatine court did convene in May 1529. The proceedings came to naught and were little more than a farce for the legates. Campeggio continued as a loyal servant of the pontiff by remaining firm in his stand against the divorce. Wolsey, perhaps a little less fervent since it was obvious Henry had no intention of marrying a French princess, was also unsuccessful. Finally, upon Clement's order, the court adjourned in midsummer, to be reconvened at Rome in October. It was clear Charles was actively using his position in Italy to force Clement's actions.⁵²

Determined not to place the future of the Tudor dynasty in the hands of the pope or the Holy Roman emperor, Henry chose to deal with the dissolution of the marriage himself. Of the pope he said,

Let him do as he wills at Rome. I will do here as I will. . .
I take the Pope to be a worthy man on the whole, but ever
since the last war he has been so afraid of the Emperor that
he dares not act against his wishes.⁵³

Henry decided to work through Parliament and so called together the assembly of Commons and Lords. When the first session met in 1529, there was one conspicuous absence. Cardinal Wolsey had been dismissed as chancellor, in part for his failure to obtain the divorce. In his place were new councillors who would utilize the new Parliament to meet the king's demands.

The actions of the English Parliament were not only to bring about the divorce, but to reorganize the English Church as an entity separate and distinct from Rome. This was an affront to Charles, the most vigorous defender of Catholicism in Europe.

Though many urged the king of England to marry Anne Boleyn before hearing sentence on Catherine, he chose to consult with Francis before making such a decision. He wanted to know exactly how far France was willing to go in defense of England against papal and Imperial actions if he went ahead with a second marriage. Specifically, Henry feared the emperor would actually declare war on England if he put Catherine away and married Anne, and he wanted a firm alliance with France if this occurred.⁵⁴ Henry may have received such assurances from the king of France, for in January 1532, he married Anne. The marriage, however, was performed in secret and was not announced until sentence had been pronounced against Catherine.⁵⁵ When the declaration came, it was made by the English Convocation of the Clergy which stated the marriage to Catherine had been contrary to divine law and was invalid.

Henry announced his marriage to Anne Boleyn in March 1533 and at the same time, readied his fleet, army, and equipment for a possible war

with Charles, Clement, or both. He wrote to the emperor, justifying his actions by saying it was the only thing he could do to insure the security of the Crown. The reaction of the pope was, as had been all his actions since 1527, one of vacillation. Certainly, he wished to take action against England, but would do so only if the emperor agreed to back him up. Much as he may have wished to, this was the very thing Charles could not do. "The time was passed when Most Catholic Princes could put armies in motion to execute the decrees of the Bishop of Rome. The theory might linger, but the facts were changed."⁵⁶ Not only would finances be a problem, but even the mustering of support for a war in the pope's behalf within the Empire, where the effects of Lutheranism had taken their toll among the German princes, was a dim prospect.

Unable to use force for the moment, Charles chose the alternative of putting aside the fact of Henry's second marriage and continuing to beseech him to keep Catherine as his wife.⁵⁷ This line of action became more difficult for the emperor to pursue as further legislation was enacted against Catherine. In March 1533, a bill was passed in Parliament stating that since the divorce sentence had been pronounced, Catherine was no longer queen, and was not entitled to the property or title which had been hers. Finally taking action, on 23 March 1534, Clement issued the Bill declaring Henry's marriage to Catherine valid and threatening excommunication if the king refused to abide by it.⁵⁸ Again, the emperor took no supportive action.

The actions of the king and his Parliament caused great unrest within England, especially among those who remained loyal to the pope. When violent suppression was inflicted upon those who would not submit to Henry, Charles, who styled himself the defender of Catholicism in Europe, became incensed. In May 1535, three Carthusian monks were executed in the streets of London for professing their loyalty to the pope.⁵⁹ In June of the same year, Henry summoned bishop Fisher of Rochester and former lord chancellor, Thomas More, to acknowledge him as head of the Anglican Church. Both refused and were executed.⁶⁰

The situation in England was becoming such that, much as he desired to avoid war, Charles could no longer refuse to act. Then, on 7 January 1536, Catherine of Aragon died, allowing the emperor to forestall the conflict and still save face.⁶¹ The original question of divorce came to a rather inconclusive end, yet the legislation enacted in England to facilitate the divorce continued to hamper Anglo-Imperial relations for many years.

A third factor greatly affecting relations between Charles V and Henry VIII was commerce. Although commercial relations between England and Spain were well established, the strongest commercial tie between the Tudors and the Hapsburgs was in the Low Countries where good relations between the two powers was of supreme importance to both.⁶² There, the English had a market for their surplus cloth and wool which the Flemings bought, finished, and dressed into luxury items.⁶³ Although the Flemings had once manufactured their own fabric, by the 1520s they relied almost totally on the more-competitively-priced English goods. Other European powers traded in the Low Countries, especially in spices, but England dominated the market.

In the previous generation, two treaties had been signed between Henry VII and Philip of the Netherlands which later set the tone for commercial relations between Flanders and England. In 1496, the two signed the agreement known as "Intercursus Magnus" which provided for free trade between Flanders and England, subject only to such dues as had been levied in the previous fifty years.⁶⁴ Then, in 1506, a second treaty was signed, the "Intercursus Malus," which first admitted English woolens to Flanders, ending the home monopoly.⁶⁵

When in 1527 Cardinal Wolsey was trying hard to implement his plan for shifting the English alliance from the Empire to France, it was generally believed the first target of his antagonism toward the Emperor would be the Flanders trade.⁶⁶ When the Flemings refused to acknowledge the permanence of the hated "Intercursus Malus," Wolsey forbade all further commerce with them. Retaliation from the emperor was swift as he prohibited the sale of English cloth in his dominions.⁶⁷ Gauging the opinion of the London merchants, Mendoza reported, "the English murmur loudly against this prohibition, as well as against the prospect of war with the Emperor."⁶⁸ Opposition among the merchants continued to swell and finally voiced itself in open rebellion. The problem started when the merchants refused to buy English cloth, so those who produced it revolted. The merchants excused their action, saying if war with the Low Countries came, they would have cloth to sell, but no one to buy it. The situation became so grave, Wolsey finally had to order the merchants to buy the fabric.⁶⁹

At the point of losing the Flanders trade, Henry realized its value and took measures to counteract Wolsey's anti-Imperial commercial policy. An eight months truce, followed by a more permanent agreement was signed with the Archduchess Margaret, regent of the Low Countries. It provided for free and undisturbed commerce between England and the Low Countries and insured mutual freedom of the seas for the purpose of fishing.⁷⁰ The truce existed on paper, yet on the seas, acts of aggression were inflicted on the merchant vessels of both powers. Henry protested Flemish vessels were daily capturing English craft and demanded Margaret to check such actions. The regent did nothing, and so, in June 1529, Henry gave orders to seize and detain Flemish craft engaging in such operations.⁷¹ Offenses were committed by the English as well, for in 1531, ambassador Chapuys protested to the Privy Council that English vessels dispatched to arrest pirates were capturing Flemish merchant craft instead.⁷²

After the fall of Cardinal Wolsey in 1529, England pursued a new commercial policy, this time under the leadership of Thomas Cromwell, formerly Wolsey's secretary. He too tried to free England from dependence on the Low Countries, but rather than shift the commercial center to France as Wolsey had proposed, Cromwell tried to make England the center of trade. The emperor's actions made it clear trade with England was as vital to the Hapsburgs as it was to the English. Threatened by the prospect of the establishment of a cloth trade in England, Charles made the supreme sacrifice of instructing Margaret not to allow Imperial opposition to Henry's divorce to interfere in any way with the Anglo-Flemish trade.⁷³

England was important to the Hapsburgs in still another way. Charles sought an English alliance in his struggle against the Turks. In 1521, the problems arising from the Turkish advance beyond Belgrade into Hungary, the conflict with France, and the Lutheran problem in the Empire were so great, Charles delegated much of his power in Eastern Europe to his brother, Ferdinand.⁷⁴ Then, in 1526, Suleiman I, sultan of the Ottoman Empire, advanced toward the Imperial state of Hungary with 200,000 men. He met the Hungarian forces at Mohacs and defeated them.

In addition to the grave situation facing the Imperial dominions in Eastern Europe, Charles had to contend with appeals for help from Christians in the Holy Land. In 1528, he informed Henry of requests for aid against the Turks made by the Knights of the Order of St. John in Jerusalem. Stating his own funds had been depleted by the conflict with France, Charles implored the king to give any support he could.⁷⁵ Henry first responded to the request by saying he would do what he could, but his own resources were small. In 1529, however, it became increasingly clear England, for several reasons, had no intention of supporting the emperor in his struggle against the Turks.⁷⁶ Thomas Howard, duke of Norfolk, told Chapuys the reason Henry would not support Charles in this effort was because he feared any increase in the emperor's power would threaten England's security.⁷⁷ By 1531, relations between Hapsburg and Tudor had deteriorated to the point that Henry accused Charles and Ferdinand of irritating and provoking the Turkish attack on Hungary.⁷⁸

One of Charles V's biographers had suggested the external threat of the Turks against the Christian world was, in the emperor's eyes, secondary in importance to the Lutheran threat within.⁷⁹ At least it must be considered as one of his major concerns. The Lutheran movement in the Empire began in 1517, and the combined attack on Church and State launched by Martin Luther was soon adopted by many of the German nobles. Throughout the 1520s, Charles appealed to Henry for aid in suppressing the Lutheran heresy in much the same way he sought aid in the struggle with the French and the Turks. In 1529, Henry, for reasons quite different from Luther's, began his own attack against the Church, an action which Charles saw as an extension of the Lutheran heresy. The emperor's perception of the Anglican Reformation was understandable because Henry incorporated Lutheran tenets into Anglicanism when it suited his purposes.⁸⁰

In 1530, the English king accused Charles of being more concerned with private affairs than the welfare of Christendom, and urged him to make certain concessions to Lutherans in the Empire.⁸¹ Later in the year, Chapuys reported he had learned the Protestant princes of Germany and France were about to form a league against the emperor, having already invited Henry to join them. Although Chapuys felt England would join and both England and France would eventually become Lutheran states, neither came to pass.⁸²

England itself did not become a Lutheran state, but by 1531, the Tudors were carrying on diplomatic negotiations with the German Lutheran princes. The English ambassador Thomas Cranmer conferred with the duke

of Saxony and others and promised English aid in their opposition to Charles. Crammer's mission might have been fruitful had not the Turkish threat prompted Charles to settle differences with the Lutherans until the situation in the East was more secure.⁸³ A similar mission was undertaken in 1534 when Dr. Robert Barnes, an Englishman formerly associated with Luther, was sent to Hamburg to gain support for Henry's divorce. After a brief return to England, he was dispatched again to arrange for Philip Melanchthon, a leading humanist and Lutheran theologian, to come to England. Melanchthon, however, refused to come.⁸⁴ Throughout the period, Charles watched as the English walked a path dangerously near Lutheranism. Though the Tudors never embraced Luther's beliefs in the form accepted by so many of the German princes, the fact that the emperor could not count them as allies against the heresy put yet another strain on Anglo-Imperial relations.

Considered together, the diplomatic events of the 1525-1535 period make it clear the nature of relations between England and the Holy Roman Empire were changing. The long standing association between the Empire and England was threatened by the divorce, by Henry's failure to assist Charles in the struggle against the Turks, and by England's attempted alliances with France and the Lutheran princes of the Empire. Such strains produced not only diplomatic animosity between the two powers, but what they felt was the very real possibility of war.

Nevertheless, war did not come, and one poses the question--why? Certain threads bound England to the Empire, and neither power, for the sake of self-preservation, could afford to sever them. In England, the tie that bound was commercial. Henry was in no position to abandon the Flanders trade, for it would mean not only economic ruin for the English wool industry, but probably domestic revolt as well. If for no other reason than to maintain commercial relations with Hapsburg dominions, Henry had to avoid an open break with Charles. At the same time, he had to consider the potential threat to English security in Charles' dream of a united Christendom. For the emperor, the situation was equally grave. Threatened in the East by the Turks and in the West by France, any European ally was of enormous importance. The task of establishing friendship with England had been accomplished long before Charles' reign, and though as Catherine's nephew and a Catholic ruler, he was bound to reprimand the English monarch for actions such as the divorce and the break with Rome, he knew stronger measures would ultimately result in the loss of England as an ally. Like Henry, Charles' hands were tied by circumstances beyond his control.

With both powers in such a quandary, diplomatic relations continued in a state of inertia. Nevertheless, the events of the previous decade had served to create a new frankness in negotiations between England and the Empire. In 1536, Charles instructed Chapuys to renew amicable relations with England but told him to make sure Henry understood the emperor did not particularly value the relationship, but considered it necessary to counteract the arrogance of France.⁸⁵

Morse

NOTES

¹Robert B. Mowat, *A History of European Diplomacy 1451-1789* (N.p.: Archon Books, 1928), p. 37.

²Neelak Serawlook Tjernagel, *Henry VIII and the Lutherans: A Study in Anglo-Lutheran Relations from 1521 to 1547* (Saint Louis: Concordia Publishing House, 1965), p. 78.

³*New Cambridge Modern History*, 12 vols. (Cambridge: University Press, 1968), 2:10.

⁴W. C. Richardson, *Stephen Vaughan, Financial Agent of Henry VIII: A Study of Financial Relations with the Low Countries* (Baton Rouge: Louisiana State University Press, 1953), p. 9.

⁵Great Britain: Public Records Office, *Calendar of Letters, Dispatches, and State Papers Relating to the Negotiations Between England and Spain, Preserved in the Archives at Simancas and Elsewhere 1485-1554*, 12 vols. (London: Her Majesty's Stationary Office, 1888; reprint, Nendeln: Kraus Reprint, 1969), vol. 3 part 1 pp. xix-xx.

⁶*Ibid.*, vol. 4 part 1 pp. v-vi; vol. 4 part 2 pp. xxvi-xxviii.

⁷E. A. Hammond, "Doctor Augustine, Physician to Cardinal Wolsey and King Henry VIII," *Medical History* 19 (July 1975): 226-228.

⁸Sir Leslie Stephen and Sir Sidney Lee, eds., *The Dictionary of National Biography*, 22 vols. (London: Oxford University Press, 1950), 6: 766.

⁹Tjernagel, *Anglo-Lutheran Relations*, pp. 71-72.

¹⁰Stephen and Lee, *Dictionary of National Biography*, 21:179.

¹¹Mowat, *European Diplomacy*, p. 37.

¹²*Ibid.*, p. 39.

¹³*Ibid.*, p. 42.

¹⁴D. B. Wyndham Lewis, *Charles of Europe* (New York: Coward McCann, 1931), pp. 9-13.

¹⁵Mowat, *European Diplomacy*, pp. 45-49.

¹⁶*Ibid.*, p. 51.

¹⁷Harold J. Grimm, *The Reformation Era: 1500-1560* (New York: Macmillan, 1973), p. 102.

¹⁸*State Papers Spanish*, Charles/Henry, 31 March 1526, vol. 3 part 1 pp. 627-628.

- ¹⁹Francisco López de Gómara, *Annals of the Emperor Charles V* (Oxford: Clarendon Press, 1912), p. 76.
- ²⁰Lewis, *Charles of Europe*, p. 107.
- ²¹*State Papers Spanish*, Charles/Edward Lee, 2 September 1526, vol. 3 part 1 p. 871.
- ²²*Ibid.*, Charles/Mendoza, 8 September 1526, vol. 3 part 1 p. 879; Henry/ Edward Lee, 21 October 1526, vol. 3 part 1 pp. 969-970.
- ²³*Ibid.*, Mendoza/Charles, 19 January 1527, vol. 3 part 2 p. 20.
- ²⁴*Ibid.*, vol. 3 part 2 p. 26.
- ²⁵In granting power of negotiation to Mendoza, Charles had stipulated that legal council from Flanders must be consulted before any action was taken by the ambassador. *Ibid.*, Mendoza/Charles, 2 March 1527, vol. 3 part 2 p. 82.
- ²⁶*Ibid.*, vol. 3 part 2 pp. 171-172.
- ²⁷Lewis, *Charles of Europe*, pp. 130-132.
- ²⁸*Ibid.*, pp. 107-108.
- ²⁹*State Papers Spanish*, Charles/Mendoza, 17 July 1527, vol. 3 part 2 pp. 282-285.
- ³⁰Alonso de Santa Cruz, *Crónica del Emperador Carlos V*, 5 vols. (Madrid: n.p., 1920), 2:327.
- ³¹*State Papers Spanish*, Mendoza/Charles, 15 November 1527, vol. 3 part 2 p. 458.
- ³²*Ibid.*, vol. 3 part 2 pp. 477-478.
- ³³*Ibid.*, vol. 3 part 2 pp. 481-485.
- ³⁴*Ibid.*, vol. 3 part 2 pp. 587-588.
- ³⁵James A. Froude, *The Divorce of Catherine of Aragon: The Story as Told by the Imperial Ambassadors Resident at the Court of Henry VIII* (New York: Charles Scribner's Sons, 1891), pp. 64-65.
- ³⁶Reginald Trevor Davies, *The Golden Century of Spain: 1501-1621* (London: Macmillan, 1937), p. 92.
- ³⁷*State Papers Spanish*, vol. 4 part 1 p. 237.
- ³⁸Froude, *The Divorce*, pp. 153-154.
- ³⁹A. F. Pollard, *Henry VIII* (London: Longmans, Green, and Co., 1951), p. 144.

⁴⁰Froude, *The Divorce*, p. 299.

⁴¹Ibid., p. 363.

⁴²There was a Biblical prohibition in Leviticus 20:21 against such a union, making papal dispensation necessary. Mowat, *European Diplomacy*, pp. 38-39.

⁴³Froude, *The Divorce*, p. 21.

⁴⁴Lewis, *Charles of Europe*, p. 108.

⁴⁵Froude, *The Divorce*, pp. 44-46.

⁴⁶Ibid., p. 38.

⁴⁷*State Papers Spanish*, Mendoza/Charles, 18 May 1527, vol. 3 part 2 pp. 193-194.

⁴⁸Froude, *The Divorce*, p. 84.

⁴⁹Grimm, *Reformation Era*, p. 242.

⁵⁰*State Papers Spanish*, Charles/Catherine, 1 September 1528, vol. 3 part 2 pp. 779.

⁵¹Froude, *The Divorce*, pp. 76-77.

⁵²Grimm, *Reformation Era*, p. 242; Froude, *The Divorce*, p. 108.

⁵³Froude, *The Divorce*, p. 162.

⁵⁴Ibid., pp. 192-193.

⁵⁵Ibid., pp. 203-204.

⁵⁶Ibid., p. 224.

⁵⁷*State Papers Spanish*, Chapuys/Charles, 7 March 1532, vol. 5 part 1 p. 72.

⁵⁸Froude, *The Divorce*, pp. 258-259.

⁵⁹*State Papers Spanish*, Chapuys/Charles, 5-8 May 1535, vol. 5 part 2 p. 452.

⁶⁰Ibid., vol. 5 part 1 pp. 507-510.

⁶¹Gómara, *Annals*, p. 100.

⁶²Richardson, *Financial Agent*, p. 4; John Bruce Williamson, *The Foreign Commerce of England Under the Tudors* (Oxford: B. H. Blackwell, 1883), pp. 22-24.

- ⁶³James A. Williamson, *Maritime Enterprise: 1485-1558* (New York: Octagon Books, 1972), p. 184; *New Cambridge Modern History*, 2:60.
- ⁶⁴*New Cambridge Modern History*, 1:244.
- ⁶⁵Mowat, *European Diplomacy*, p. 39.
- ⁶⁶*State Papers Spanish*, Mendoza/Charles, 18 March 1527, vol. 3 part 2 p. 109.
- ⁶⁷Williamson, *Foreign Commerce*, pp. 34-35.
- ⁶⁸*State Papers Spanish*, Mendoza/Charles, 4 June 1527, vol. 3 part 2 p. 229.
- ⁶⁹David Macpherson, *Annals of Commerce, Manufacturies, Fisheries, and Navigation, with Brief Notices of the Arts and Sciences Connected with Them*, 4 vols. (London: Nichols and Son, 1805), 2:69-70.
- ⁷⁰Adam Anderson, *An Historical and Chronological Deduction of the Origin of Commerce From the Earliest Accounts Containing an History of the Great Commercial Interests of the British Empire*, 4 vols. (New York: Augustus Kelly, 1967), 2:50.
- ⁷¹*State Papers Spanish*, Henry/Margaret, 7 June 1529, vol. 4 part 1 pp. 68-69.
- ⁷²*Ibid.*, Chapuys/Charles, 30 January 1531, vol. 4 part 2 p. 377.
- ⁷³Williamson, *Foreign Commerce*, pp. 35-36.
- ⁷⁴By the Family Pact of Worms in 1521, Ferdinand was given ducal powers in Upper and Lower Austria, Styria, Carinthia, and Carniola. These territories were extended in 1522 by the Treaty of Brussels, making Ferdinand regent in Vorarlber, Tyrol, and Anterior Austria. Robert A. Kann, *A History of the Hapsburg Empire 1526-1918* (Berkeley: University of California Press, 1974), pp. 27-28; Hajo Holborn, *A History of Modern Germany: The Reformation* (New York: Alfred A. Knopf, 1959), p. 157.
- ⁷⁵*State Papers Spanish*, Charles/Henry, 12 September 1528, vol. 3 part 2 p. 786.
- ⁷⁶*Ibid.*, Chapuys/Charles, 17 November 1529, vol. 4 part 1 pp. 330-342.
- ⁷⁷*Ibid.*, Chapuys/Charles, 11 July 1530, vol. 4 part 1 p. 632.
- ⁷⁸*Ibid.*, Chapuys/Charles, 21 February 1531, vol. 4 part 1 p. 72.
- ⁷⁹Kann, *Hapsburg Empire*, p. 36.
- ⁸⁰*State Papers Spanish*, Chapuys/Charles, 17 November 1529, vol. 4 part 1 p. 350.

⁸¹Ibid., Chapuys/Charles, 7 November 1530, vol. 4 part 1 p. 799.

⁸²Froude, *The Divorce*, p. 135.

⁸³Tjernagel, *Anglo-Lutheran Relations*, pp. 71-72; Johannes Janssen, *History of the German People at the Close of the Middle Ages*, 16 vols., A. M. Christie, trans. (New York: AMS Press, 1966), 5:367-368.

⁸⁴Richard G. Eaves, "The Reformation Thought of Dr. Robert Barnes, Lutheran Chaplain and Ambassador for Henry VIII," *Lutheran Quarterly* 28 (May 1976): 156-165.

⁸⁵Karl Brandi, *The Emperor Charles V: The Growth and Destiny of a Man and of a World Empire*, C. V. Wedgwood, trans. (New York: Alfred A. Knopf, 1939), pp. 374-375.

A LOOK AT ALTERNATIVE PRODUCT DISTRIBUTION SYSTEMS^{1,2}

William E. Hardy, Jr. and Vayden L. Murphy, Jr.
Department of Agricultural Economics and Rural Sociology
Alabama Agricultural Experiment Station
Auburn University
Auburn, AL 36830

In an inflationary economy, most phases of the production and marketing system receive criticism and blame for price increases. When food products are discussed, middlemen are often cited as being responsible for a large portion of increased costs. These individuals receive nearly 60 percent of the retail market cost of farm produced products for the processing, packaging, advertising and distribution services they perform [4].

Since a substantial share of the retail cost of food products is generated by middlemen, increased efficiency in their operations could have significant effects on future food prices. The research results presented in this paper represent an examination into one area of the food marketing and distribution system where increased efficiency and resultant cost savings might be realized through changes in existing policy and practices. The area of concern is vehicle routing and scheduling.

PROBLEM

Product delivery and distribution to retail outlets and/or customers are major functions performed by many middlemen. Most who perform these marketing services have established fixed routes which their vehicles follow in delivering the product. In most cases, these routes have been developed over several years with little thought given to their over-all efficiency. As businesses and their service areas have grown, customers have typically been added to existing routes and when a route became too large, another was started.

When diesel fuel was \$.20 per gallon and drivers worked for \$1.50 per hour, there was little concern with transportation costs. Transportation was considered somewhat as a "necessary evil" with little opportunity for businesses to escape from having to deliver their products. Current cost conditions, however, are such that every alternative for increased efficiency must be examined.

¹Manuscript received 24 April 1979; accepted 25 June 1979.

²Research on which this report is based was supported by Federal and State research funds under Hatch Project Alabama 638.

In addition to the possibility that each route may not be designed in the most efficient manner, another practice followed by many delivery systems could result in increased costs. This policy is to require that the routing network be established so that each driver follows basically the same route each day, thus each customer would always be served by the same driver. In the past when most routemen were also salesmen, this practice was important in that it generated increased sales. With extensive home office contacts, volume purchases, and contracts for quantities of a given product made between a distributor and retailer, contacts and sales made by the driver are no longer an important part of business. More efficient and less expensive routes could be developed if each delivery day were considered independently.

PROCEDURE

Techniques have been available for many years to aid management in the evaluation and development of efficient and least-cost vehicle routing and scheduling systems. These procedures range from simple hand calculations [7] to sophisticated computer assisted algorithms [2]. Turner, Ghare, and Fourds [8] present a detailed survey of the current status of procedures for solving routing problems. They indicate that even though models are available which guarantee optimal routing systems, these methods are seldom used on large-scale real-world problems. Computational time and effort required for such models is often prohibitive, leading to the use of heuristic procedures.

The heuristic procedure developed by Clarke and Wright [1] in 1964 and extensions of the technique have proved to be very useful and effective in the development of efficient and least-cost routing networks [3, 5, 6]. This procedure was selected for use to aid in the development of improved routing networks for a selected case-study firm.

The basic logic followed by the version of the Clarke-Wright procedure used in this study [2] is as follows. The objective to be satisfied in establishing the routing network is that total travel distance be minimized. Distance is used as a surrogate measure of cost. The first result obtained in using the model is the maximum cost solution and improved networks follow. The maximum cost solution has each delivery point on individual routes so that the total cost to the system would be

$$(1) \text{ TC} = 2 \sum_j C_{oj}$$

for symmetrical problems, and

$$(2) \text{ TC} = \sum_j C_{oj} + \sum_j C_{jo}$$

for asymmetrical problems. C_{oj} and C_{jo} respectively represent the distance between the origin o , and each delivery point j , and each delivery point and the origin.

The next step in route development is to calculate savings coefficients, S_{ij} , which represent the amount of distance saved if two stops

Alternative Product Distribution Systems

are joined on the same route.

$$(3) S_{ij} = C_{i0} + C_{0j} - C_{ij}$$

If two stops are joined on a route, then a trip from the first stop back to the origin, C_{i0} , and a trip from the origin to the second stop, C_{0j} , are eliminated. An additional cost representing the travel between stops i and j , C_{ij} , is added, however.

Savings coefficients for all possible combinations of stops taken two at a time are calculated and arranged in descending order. Routes are then developed with delivery points being linked together based on maximum savings coefficients. Stops can be joined on a route if both are still linked to the origin and both are on separate routes prior to the linking. In addition, for this analysis, delivery time constraints for some stops and truck capacity limitations were imposed on route development.

RESEARCH RESULTS

The case study firm selected for analysis was assumed to be representative and typical of other wholesale milk distribution operations. The market area served by the example firm includes eight counties, a major city, and several small towns and communities. An excess of 600 wholesale customers including grocery and convenience stores, restaurants, schools, churches, hospitals, and service stations are served.

The data given in Table 1 represent the existing system used by the firm in delivering its product. Nearly 1,900 deliveries are made per week, requiring over 6,800 miles of travel. Almost 736 hours of service time was required each week with the 90 weekly routes averaging about eight hours. Variable weekly vehicle cost was estimated to be \$1,299 and the labor expense for each week's operation was \$4,054. Annual fixed cost per vehicle was estimated to be \$5,302.

The existing system requires 18 operational vehicles with two stand-bys. Annual operation of this delivery operation requires a total expenditure of \$384,393--\$106,050 fixed cost, \$67,556 variable vehicle cost, and \$210,787 labor cost.

Table 2 represents information on the improved routes that were developed on a weekly schedule. With the assumption of weekly routes, customers are always served by the same driver. Because of the small number of customers on Tuesday and Thursday, some routes were combined.

With the improved routing network, it was estimated that all customers could be served by 84 daily routes in a little more than 532 hours per week, giving an average time per route of 6.3 hours and average length of 60.25 miles. Variable cost for operating the fleet was projected to be \$961.54 with a weekly labor cost of \$3,783.55.

When routes were reorganized with each day treated independently and having no influence on the routes of other days, total time required

Table 1. Routes for existing system.

	<u>Number of routes</u>	<u>Total miles</u>	<u>Average miles/ route</u>	<u>Total customers</u>	<u>Average customers/ route</u>	<u>Total time</u>	<u>Average time/ route</u>	<u>Variable cost</u>	<u>Labor cost</u>
	<u>Number</u>	<u>Miles</u>	<u>Miles</u>	<u>Number</u>	<u>Number</u>	<u>Hours</u>	<u>Hours</u>	<u>Dollars</u>	<u>Dollars</u>
Monday	18	1,630.71	90.60	549	30.67	181.00	10.06	309.83	810.72
Tuesday	11	477.30	43.39	46	4.18	43.39	3.95	90.69	495.44
Wednesday	18	1,469.29	81.63	488	28.00	178.53	9.92	279.17	810.72
Thursday	11	477.30	43.39	46	4.18	43.39	3.95	90.69	495.44
Friday	18	1,603.56	89.09	525	29.89	184.67	10.26	304.68	810.72
Saturday	14	1,179.41	84.24	234	18.00	104.67	7.48	224.09	630.56
Total/average	90	6,837.57	75.97	1,888	21.53	735.65	8.17	1,299.15	4,053.60

Alternative Product Distribution Systems

Table 2. Improved routes developed on a weekly basis.

	Number of routes	Total miles	Average miles/route	Total customers	Average customers/route	Total time	Average time/route	Variable cost	Labor cost
	Number	Miles	Miles	Number	Number	Hours	Hours	Dollars	Dollars
Monday	18	1,140.09	63.34	549	30.5	136.1	7.6	216.62	810.76
Tuesday	6	294.12	49.02	46	7.7	24.2	4.0	55.88	270.25
Wednesday	18	1,188.88	66.05	488	27.1	132.4	7.4	225.89	810.76
Thursday	6	294.12	49.02	46	7.7	24.2	4.0	55.88	270.25
Friday	18	1,185.14	65.84	525	29.2	135.9	7.6	225.18	810.76
Saturday	18	958.34	53.24	234	13.0	79.6	4.4	182.09	810.76
Total/average	84	5,060.69	60.25	1,888	22.5	532.4	6.3	961.54	3,783.55

for delivery was estimated to be 520 hours, Table 3. The average time per route was seven hours and average length was 60.76 miles. Variable cost for this delivery system was estimated to be \$852.29 and labor expense is \$3,333.09.

A comparison of the characteristics of the existing delivery network with the two improved systems is presented in Table 4. The data show that substantial savings in travel, travel time, and cost are possible through route reorganization. When the constraint of a weekly routing pattern is imposed with each customer being served by the same driver, costs associated with delivery are reduced significantly, \$617.66 per week for an 11 percent decrease. The number of trips required to serve all customers each week is reduced from 90 to 84 and weekly travel is decreased 26 percent to a little more than 5,000 miles.

Route development with each day considered independently makes an even more efficient delivery network possible. The total number of trips is reduced to 74 and total travel to 4,496 miles, a 34 percent reduction from the existing level. Average miles per route is 20 percent less than the current system and slightly more than that projected for the improved weekly network.

Variable and labor costs associated with the system are 22 percent less than those currently being realized. The savings were generated through weekly savings of \$446.86 in variable cost and \$720.51 in labor cost. These savings could mean an annual cost reduction of over \$60,000. In addition, since the number of routes is reduced significantly, one less truck would be required, giving annual savings of \$5,302.

A comparison of the total annual costs of operating the existing delivery system and the two proposed improved networks indicates the savings that can be realized through more efficient vehicle scheduling and routing. The possibility for substantial savings by developing routes on an individual daily basis can also be seen. Total annual cost is reduced by eight percent with the weekly route condition is imposed and by 17 percent when each day is considered independently.

SUMMARY

Rising prices for petroleum products and similar increases in wages and benefits for labor have put upward pressure on the costs of transportation. A positive approach to treating this problem is to carefully examine the actual routes vehicles are traveling and the sequence of stops on the routes. The research results presented in this report illustrate the possibility of substantial savings through route reorganization. Variable and labor costs for the example operation used in this analysis could be reduced as much as 22 percent, giving an annual savings of over \$60,000. Cost reductions of this magnitude are significant and indicate that conscientious route managers should consider route reorganization as a means for reducing costs or possibly increasing service and customers for little additional cost.

Table 3. Improved routes developed with each day treated independently.

	Number of routes	Total miles	Average miles/ route	Total customers	Average customers/ route	Total time	Average time/ route	Variable cost	Labor cost
	<u>Number</u>	<u>Miles</u>	<u>Miles</u>	<u>Number</u>	<u>Number</u>	<u>Hours</u>	<u>Hours</u>	<u>Dollars</u>	<u>Dollars</u>
Monday	17	1,082.31	63.67	549	32.3	133.8	7.9	205.64	765.71
Tuesday	6	292.23	48.71	46	7.7	24.1	4.0	55.52	270.25
Wednesday	17	1,042.68	61.33	488	28.7	129.2	7.6	198.11	765.71
Thursday	6	292.23	48.71	46	7.7	24.1	4.0	55.52	270.25
Friday	17	1,078.47	63.44	525	30.9	132.8	7.8	204.91	765.71
Saturday	<u>11</u>	<u>708.39</u>	<u>64.40</u>	<u>234</u>	<u>21.3</u>	<u>75.9</u>	<u>6.9</u>	<u>134.59</u>	<u>495.46</u>
Total/average	74	4,496.31	60.76	1,888	25.5	519.9	7.0	852.29	3,333.09

Table 4. Comparison of existing delivery routes with improved systems developed using "lockset method" for week's operation.

	Existing system	Improved weekly routes	Improved daily routes
Number of routes	90	84	74
Total miles	6,837.57	5,060.69	4,496.31
Average miles/route	75.97	60.25	60.76
Total time (hours)	735.65	532.4	519.9
Average time/route (hours)	8.17	6.3	7.0
Variable cost (dollars)	1,299.15	961.54	852.29
Labor cost (dollars)	4,053.60	3,783.55	3,333.09
Annual fixed cost (dollars)	106,050.20	106,050.20	100,747.69
Total annual cost (dollars)	384,393.20	352,794.88	318,387.45

SELECTED REFERENCES

- [1] Clarke, G. and J. W. Wright. "Scheduling of Vehicles from a Central Depot to a Number of Delivery Points." *Oper. Res.* 12 (1964:568-81).
- [2] Hallberg, M. C. and W. R. Kriebel. *Designing Efficient Pickup and Delivery Route Systems by Computer.* Penn. Agr. Exp. Sta. Bull. 728, June 1972.
- [3] _____ and G. T. Gentry. *Efficient Routing System for Retail Milk Delivery.* Penn. Agr. Exp. Sta. Bull. R.S. 91, 1970.
- [4] Hardy, W. E., Jr. "Factors Behind Rising Food Costs--Should the Farmer be Blamed?" *Highlights of Agricultural Research.* Agricultural Experiment Station, Auburn University, Auburn, Alabama, Vol. 23, No. 2, Summer, 1976.
- [5] _____ and Curtis L. Grissom. "An Economic Analysis of a Regionalized Rural Solid Waste Management System." *American Journal of Agricultural Economics,* Vol. 58, No. 2, May, 1976.
- [6] Schruben, L. W. and R. E. Clifton. "The Lockset Method of Sequential Programming Applied to Routing Delivery and Pickup Trucks." *Amer. J. Agr. Econ.* 50(1968):854-67.

Alternative Product Distribution Systems

- [7] Shuster, K. A. and D. A. Shur. *Heuristic Routing for Solid Waste Management*. U.S. EPA Publ. SW-131, 1974.
- [8] Turner, Wayne C., Prabhakar M. Ghare, and Leslie R. Fourds. "Transportation Routing Problem, A Survey." *AIIE Trans.* 6(1974):288-301.

STATUS OF THE COYOTE AND RED WOLF IN ALABAMA¹

Thomas W. French² and Julian L. Dusi
Department of Zoology-Entomology
Auburn University
Auburn, AL 36830

The taxonomic status and distribution of the coyote, *Canis latrans*, in the eastern United States is at present poorly understood. Specimen records are generally few and spotty. In the late 1800's, an eastward expansion of the range began (Gipson 1978). Coyotes were first noted in Louisiana in 1949 (Goertz et al. 1975) and in Mississippi at least as early as 1966 (Paradiso 1966). In Arkansas, coyotes first appeared in the early 1920's and by as early as 1964 the range included the entire state (Gipson et al. 1974). Red wolves, *Canis rufus*, were considered extirpated over much of their range by 1900 (Young and Goldman 1944). Gipson (1978) believes that "no wild *Canis*, other than occasional feral dogs and extremely isolated pockets of red wolves, occurred in southern states east of the Mississippi River from 1900 until about 1965."

Several early introductions of coyotes, however, have been documented. Some of the earliest occurred in Palm Beach and DeSoto counties, Florida in 1925 (Cunningham and Dunford 1970) and in Georgia in the early 1940's (Wohlgemuth 1968). The only known introduction in Alabama occurred in the late 1950's at Redstone Arsenal, near Huntsville but all of the introduced coyotes are reported to have been removed during an eradication program in 1961 (Linzey 1971).

Examination of the available Alabama specimens revealed two strikingly different color types. The light phase is typical of the species and almost certainly is that of all the western coyotes released in the East. The second color type is very dark or melanistic and seemingly identical in appearance and pattern to the black phase of the red wolf. Melanistic coyotes have previously been reported from eastern Texas (McCarley 1959), Oklahoma (Holloran 1963), Arkansas (Pimlott and Joslin 1968, Gipson 1976) and Louisiana (Goertz et al. 1975). Three black coyotes or coyote hybrids from Mississippi are in the Mississippi Museum of Natural Science, in Jackson (MMNS 547, 5872, 6026). In Alabama, at least eight black coyotes, or coyote hybrids, have been taken; records are available from Lee, Pickens, Russell, and Wilcox counties (Figure 1). Similarities in distribution of black coyotes and the former range of the

¹Manuscript received 2 May 1979; accepted 11 June 1979.

²Current address: Department of Life Sciences, Indiana State University, Terre Haute, Indiana 47809.

The Coyote and Red Wolf in Alabama

red wolf are probably not coincidental. We feel, as do Goertz et al. (1975), that the black pelt color is a lingering genetic trait resulting from past hybridization with the red wolf.

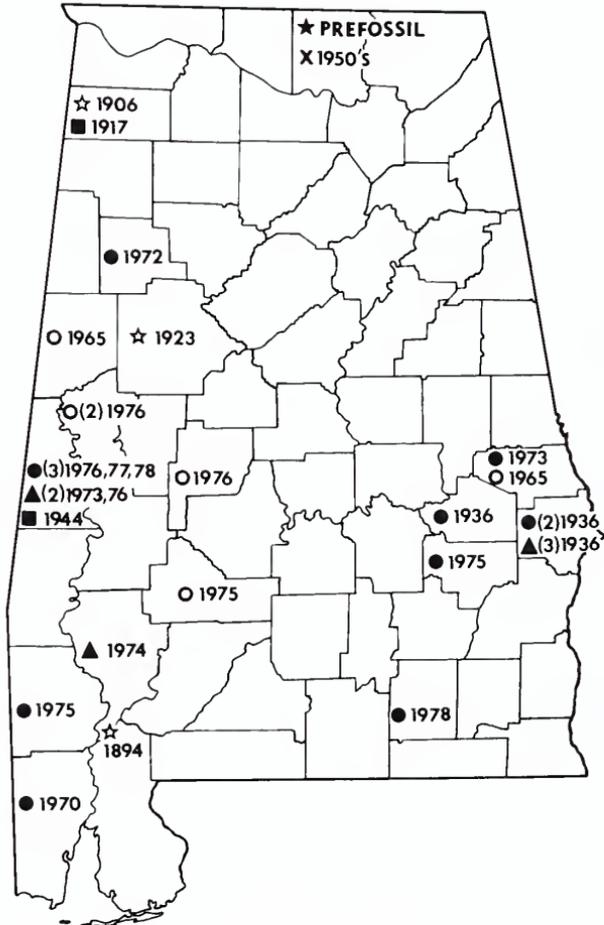


Figure 1. Distribution and date records of coyotes (circles), red wolves (stars), possible red wolf-coyote hybrids (squares) and possible coyote-dog hybrids (triangles) in Alabama. The X represents a known coyote introduction site. Open symbols represent mounted specimens, photographs and literature records. Closed symbols represent museum specimens.

Whether red wolves lingered in Alabama late enough to come in contact with introduced or pioneering coyotes is not clear. Red wolves have been reported taken near Carlton, Clark-Baldwin county line in 1894 (Howell 1921) and near Cherokee, Colbert County, in 1917 (Goldman 1937, Young and Goldman 1944, USNM 223936). A "black wolf" was reported to have been killed on LaGrange Mountain, near Leighton, Colbert County, about 1906 (Howell 1921). The Alabama Department of Game and Fisheries (1925) reported another "wolf" weighing over 70 pounds (31.8 Kg.) killed in Tuscaloosa County in 1923 and a 57 pound (25.9 Kg.) specimen (USNM 274520) was collected at Livingston, Sumter County, in 1944.

Unfortunately, only the Colbert (1917) and Sumter County specimens are still available for examination. Both of these animals agree in most characters with *Canis rufus* but have palatal ratios of less than 3.1 (Table 1), which usually separates dogs, *Canis familiaris*, dog-coyote, or dog-wolf hybrids (John A. Sealander, pers. comm.). It is suggested, therefore, that these two most recent specimens represent red wolf-dog hybrids, rather than pure red wolves. The only other report of the red wolf from Alabama is a prefossil partial skeleton from Fern Cave, Jackson County (Paradiso and Nowak 1973, USNM 348063). This animal seems to agree in size and proportions with *Canis rufus*.

Eight possible coyotes or coyote hybrids are known from Alabama prior to 1970 (Figure 1). Five of these are black, two light-colored and one of unknown color. Thirteen cranial and body characters were examined from seven of these and from 13 more recent specimens. Selected measurements appear in Table 1. Positive identification of individual specimens is sometimes not possible. Generally, in coyotes, red wolves and coyote-red wolf hybrids, (1) the rostrum is less than 18 per cent as wide as the greatest skull length; (2) the inner lobe of fourth upper premolar is poorly developed or absent; (3) the length of the upper molariform toothrow divided by the width of the palate between the inner margins of the alveoli of the first upper premolars equals 3.1 or more; and (4) the frontal shield is flat. Specimens with different cranial characters are usually considered dog, or dog-coyote, or dog-red wolf hybrids (Sealander, pers. comm.). Other characters, within which some overlap occurs, include (1) a total skull length less than about 215 mm (Goertz et al. 1975) and (2) coyotes have upper canines whose antero-posterior widths at the gum line are usually 10 mm or less. Red wolf measurements are usually larger. Three preserved specimens in the National Museum (USNM 203745, 262123, 347473) were considered *Canis familiaris* by us because their measurements did not fit these criteria.

Measurements in Table 1 suggest that coyotes and coyote hybrids did exist in Alabama before 1965; however, most specimens have appeared after 1970. We agree with Gipson (1978) that the current population of wild *Canis* in Alabama, other than feral dogs, is predominately coyote-like but may show a slight shift in characters toward *Canis rufus*. This is most apparent by the presence of animals consistently exceeding 31 pounds (14 Kg.) and the presence of the black pelt color.

The authors wish to thank Barbara Bacon (U.S. National Museum) and David H. Nelson (University of South Alabama) for measuring specimens

Table 1. Selected data from wild *Canis* taken in Alabama. The palatal ratio is the length of the upper molariform toothrow divided by the width of the palate between the inner margins of the alveoli of the first upper premolars. The canine width is the antero-posterior width of the upper canine. Museum abbreviations are USNM (U.S. National Museum), AJM (Auburn University Museum) and USA (University of South Alabama).

	Museum number	County	Sex	Weight (kg)	Skull length (mm)	Palatal ratio	Width of canine (mm)	Collection date	Color type
<u>Red Wolf</u>									
<u>Probable coyotes</u>									
	USNM 348063	Madison	♂	--	228	3.30	11.7	prefossil	--
	USNM 262122	Russell	♀ juv.	--	173	3.30	--	23 Sept. 1936	--
	262126	Russell	♂ juv.	--	182	3.27	9.3	10 Nov. 1936	black
	262128	Macon	♂	--	181	3.53	9.0	18 Nov. 1936	light
	514358	Sumter	♀	16.8	204	3.12	9.0	17 Dec. 1976	light
	526886	Sumter	♂	16.3	--	3.70	9.2	25 Nov. 1977	black
	526887	Sumter	♀	14.5	188	3.16	9.6	3 Jan. 1978	light
	AJM 6-80	Lee	♀	14.1	197	3.45	9.1	1 May 1973	black
	6-94	Bulloch	♂	--	182	3.55	8.4	1 July 1975	light
	6-97	Washington	♀ juv.	6.8	172	3.66	8.7	27 Oct. 1975	light
	6-120	Coffee	♀	9.3	183	3.64	8.2	10 Jan. 1978	light
	USA 760	Mobile	♂	13.2	210	3.71	9.2	23 Feb. 1970	light
	979	Fayette	--	--	194	3.43	9.0	1972	--
<u>Possible coyote-dog hybrids</u>									
	USNM 262124	Russell	♀ juv.	6.8	168	2.91	8.3	26 Sept. 1936	black
	262125	Russell	♂	--	197	2.92	9.9	10 Oct. 1936	black
	262127	Russell	♀ juv.	--	170	3.00	8.0	14 Nov. 1936	black
	514357	Sumter	♂	15.9	195	2.91	10.3	17 Dec. 1976	light
	AJM 6-93	Clarke	♀	--	193	3.07	8.7	Fall 1974	light
	USA 845	Sumter	♀	12.8	197	3.01	8.9	18 Feb. 1973	light
<u>Possible red wolf-dog hybrids</u>									
	USNM 223936	Colbert	♂	--	235	2.77	13.6	24 Mar. 1917	light
	274520	Sumter	♂	25.9	227	2.69	11.5	11 Oct. 1944	light

under their care. We also wish to thank John O. Whitaker for reviewing the manuscript.

LITERATURE CITED

- Alabama Department of Game and Fisheries. 1925. Some birds, game and fish of Alabama. Birmingham Printing Co. 151 pp.
- Cunningham, V. D., and R. D. Dunford. 1970. Recent coyote record from Florida. Quarterly Journ. Fla. Acad. Sci. 33: 279-280.
- Gipson, P. S. 1976. Melanistic *Canis* in Arkansas. The Southwestern Naturalist 21: 124-126.
- _____. 1978. Coyotes and related *Canis* in the Southeastern United States with a comment on Mexican and Central American *Canis*. 190-208. In: Bekoff, M. (Ed.) Coyotes--Biology, Behavior and Management. Academic Press, N.Y. 384 pp.
- _____, J. A. Sealander, and J. E. Dunn. 1974. The taxonomic status of wild *Canis* in Arkansas. Systematic Zoology 23: 1-11.
- Goertz, J. W., L. V. Fitzgerald, and R. M. Nowak. 1975. The status of wild *Canis* in Louisiana. The Amer. Midl. Naturalist 93: 215-218.
- Goldman, E. A. 1937. The wolves of North America. J. Mamm. 18: 37-45.
- Halloran, A. F. 1963. A melanistic coyote from Oklahoma. Southwestern Naturalist 8: 48-49.
- Howell, A. H. 1921. Mammals of Alabama. North Amer. Fauna 45: 1-88.
- Linzey, D. W. 1971. Animal harvested in south Alabama probably coyote-red wolf hybrid. Ala. Cons. Mag. Dec. 1971: 6-7.
- McCarley, H. 1959. The mammals of eastern Texas. The Texas Journal of Science 11: 385-426.
- Paradiso, J. L. 1966. Recent records of coyotes, *Canis latrans*, from the Southeastern United States. Southwestern Naturalist 11: 500-501.
- _____, and R. M. Nowak. 1973. New data on the red wolf in Alabama. J. Mamm. 54: 506-509.
- Pimlott, D. H., and P. W. Joslin. 1968. The status and distribution of the red wolf. Trans. N. Amer. Wildl. Nat. Resour. Conf. 33: 373-389.
- Wohlgenuth, D. 1968. Coyote culprits. Georgia Game and Fish 3(10): 9-10.
- Young, S. P., and E. A. Goldman. 1944. The wolves of North America. Am. Wildl. Inst., Wash., D.C. 363 pp.

FUNGI OF ALABAMA. VIII.
SOME HIGHER SPECIES OF THE AUBURN AREA¹

D. J. Gray and G. Morgan-Jones
Department of Botany and Microbiology
Auburn University Agricultural Experiment Station
Auburn, AL 36830

Abstract. A list of higher fungi (Ascomycotina and Basidiomycotina) collected in and around Auburn, Lee County, Alabama, during a three year period (1976-1979) is presented.

INTRODUCTION

Relatively few intensive floristic studies of Alabama fungi have been published. The lists of fungi published by Atkinson (1897), Underwood and Earle (1897) and Mohr (1901) remain the only major documentations of the state mycoflora. These lists, although still useful, incorporate only a small percentage of the fungi expected to occur here. They are also of limited utility because of outdated nomenclature and the innumerable taxonomic changes which have occurred in the intervening three quarters of a century.

Previous papers in this series have been devoted predominantly to hyphomycetous microfungi. In the present publication the occurrence of some macrofungi is recorded. Like the microfungi a number of these attest to new records for the state. Specimens of each taxon are on deposit in the Auburn University Mycological Herbarium.

In this list of higher fungi only collections made in Auburn and its vicinity are documented. As more collections are made in future years, further lists will be published for both this area and other regions of the state.

Four main study areas were selected based on differing habitat types. In the list species association with these is indicated by the numerical system below. Where some overlap occurs in the macrofungal components of these areas two or more numbers are noted after a given species.

1. Weedy places, yards, roadsides and other disturbed areas (within Auburn city limits).
2. Regularly mowed fields and pasture lands (within a ten-mile radius of Auburn).

¹Manuscript received 9 August 1979; accepted 6 September 1979.

Gray and Morgan-Jones

3. Pine dominance: little hardwood understory (northwestern corner of Tuskegee National Forest).
4. Pine dominance: moderate hardwood understory (Chewacla State Park).

LIST OF SPECIES

Taxonomic treatment of orders and families is according to Dennis (1968) for the Ascomycotina and Singer (1962) for the Agaricales.

Ascomycotina

Helotiales

Geoglossaceae

- Leotia chlorocephala* Schw. (3)
Leotia lubrica Pers. (3)

Pezizales

Helvellaceae

- Helvella acetabulum* (St. Amans) Quel. (3,4)
Helvella corium (Weberb.) Massee (4)
Helvella crispa Fr. (4)

Humariaceae

- Aleuria aurantia* (Fr.) Fuckel (4)

Sarcoscyphaceae

- Urmula craterium* (Schw.) Fr. (4)

Basidiomycotina

Agaricales

Amanitaceae

- Amanita caesarea* (Fr.) Schw. (3,4)
Amanita chlorinosma (Austin) Lloyd (4)
Amanita flavoconia Atk. (3,4)
Amanita flavorubescens Atk. (3)
Amanita inaurata Secr. (1)
Amanita muscaria (Fr.) S. F. Gray (3,4)
Amanita rubescens (Pers. ex Fr.) S. F. Gray (1,3,4)
Amanita vaginata (Fr.) Vitt. (1,3,4)
Amanita verna (Fr.) Quel. (3,4)
Amanita virosa (Fr.) Quel. (3,4)

Fungi of Alabama

Russulaceae

- Lactarius fuliginosus* Fr. (4)
- Lactarius indigo* (Schw.) Fr. (3,4)
- Lactarius zonarius* (Secr.) Fr. (3,4)
- Russula emetica* (Fr.) Pers. (3,4)
- Russula virescens* Fr. (3,4)
- Russula xerampalina* Fr. (3,4)

Lepiotaceae

- Chlorophyllum molybdites* Masee (1)
- Lepiota cristata* (Alg. and Schw. ex Fr.) Kummer (3,4)
- Lepiota lutea* (Bolt.) Quel. (1)
- Lepiota procera* (Fr.) Kummer (2)
- Leucoagaricus naucina* (Fr.) Sing. (1)

Tricholomataceae

- Armillariella mellea* (Fr.) Karst. (3,4)
- Claudopus nidulans* Fr. (3)
- Clitocybe nuda* (Fr.) Bigelow and Smith (3,4)
- Clitocybe robusta* Peck (3)
- Collybia radicata* (Fr.) Quel. (3,4)
- Laccaria laccata* (Fr.) Berk. and Br. (2)
- Laccaria ochropurpurea* (Berk.) Peck (4)
- Marasmius cohortalis* Berk. (1)
- Marasmius pallescens* Murr. (3)
- Marasmius rotula* (Fr.) Kummer (3,4)
- Marasmius siccus* (Schw.) Fr. (3,4)
- Mycena alcalina* (Fr.) Quel. (3,4)
- Mycena pura* (Fr.) Quel. (3)
- Pleurotus sapidus* (Schulzer) Kalch. (3,4)

Hygrophoraceae

- Hygrophorus acutoconicus* (Clem.) Smith (3,4)
- Hygrophorus coccineus* (Fr.) Fr. (3,4)
- Hygrophorus conicus* (Fr.) Fr. (3,4)
- Hygrophorus miniatus* (Fr.) Fr. (3,4)
- Hygrophorus nitidus* Berk. and Curt. (3,4)

Entolomataceae

- Entoloma abortivum* (Berk. and Curt.) Donk (3,4)

Pluteaceae

- Pluteus admirabilis* (Peck) Peck (3,4)
- Pluteus cervinus* (Schaeff. ex Fr.) Kummer (3,4)
- Volvariella bombycina* (Schaeff. ex Fr.) Singer (4)

Gray and Morgan-Jones

Agaricaceae

- Agaricus arvensis* Fr. ex Schaeff (1,2)
- Agaricus campestris* Fr. (1)
- Agaricus placomyces* Peck

Strophariaceae

- Naematoloma fasciculare* (Huds. ex Fr.) Karst. (3,4)
- Psilocybe coprophila* (Bull. ex Fr.) Kummer (2)
- Psilocybe cubensis* (Earle) Singer (2)

Coprinaceae

- Coprinus atramentarius* (Bull. ex Fr.) Fr. (1)
- Coprinus comatus* (Mull. ex Fr.) S. F. Gray (1,2)
- Coprinus micaceus* (Bull. ex Fr.) Fr. (1,2)
- Panaeolus campanulatus* (L.) Quel. (2)
- Panaeolus foenisecii* (Fr.) Kuehn. (2)

Cortinariaceae

- Cortinarius alboviolaceus* (Fr.) Kummer (3,4)
- Cortinarius violaceus* (Fr.) S. F. Gray (3)
- Hebeloma crustuliniforme* (Bull. ex St. Amans) Quel. (1)
- Inocybe fastigiata* (Schaeff. ex Fr.) Quel. (3,4)

Boletaceae

- Boletellus ananus* (Curt.) Murr. (4)
- Boletellus russellii* (Frost) Gilbert (3,4)
- Boletus auriporus* Peck (3,4)
- Boletus ornatipes* Peck (3,4)
- Phylloporus rhodoxanthus* (Schw.) Bres. (4)
- Pulveroboletus ravenelii* (Berk. and Curt.) Murr. (3,4)
- Strobilomyces floccopus* (Vahl. ex Fr.) Karst. (3,4)

Cantharellaceae

- Cantharellus cibarius* Fr. (3,4)
- Cantharellus cinnabarinus* Schw. (3,4)
- Craterellus cantharellus* (Schw.) Fr. (3,4)
- Craterellus cornucopioides* Fr. (3,4)

Aphyllorphorales

Hydnaceae

- Hydnellum diabolis* Banker (4)
- Hydnum imbricatum* Fr. (4)
- Hydnum scabrosum* Fr. (4)

Fungi of Alabama

Polyporaceae

- Lenzites betulina* (Fr.) Fr. (3,4)
- Lenzites saeptaria* (Fr.) Fr. (3,4)
- Polyporus arcularius* Batsch ex Fr. (2,3,4)
- Polyporus versicolor* L. ex Fr. (3,4)
- Poria papyracea* (Schw.) Cooke (1)
- Pycnoporus cinnabarinus* (Fr.) Karst. (3,4)
- Pycnoporus sanguineus* (Fr.) Karst. (3,4)

Stereaceae

- Stereum frustulosum* Fr. (3)

Thelephoraceae

- Thelephora terrestris* (Fr.) Ehrh. (3)

Sparassidaceae

- Sparassis crispa* Wulfen (1,4)
- Sparassis radicata* Weir (4)

Clavariaceae

- Clavaria zollingeri* Lév. (4)
- Clavicorona pyxidata* (Fr.) Doty (3,4)

Auriculariales

Auriculariaceae

- Auricularia auricula* (Hook.) Underwood (3,4)

Dacrymycetales

Dacrymycetaceae

- Dacrymyces palmatus* (Schw.) Bres. (3,4)

Tremellales

Tremellaceae

- Tremella mesenterica* (S. F. Gray) Pers. (3,4)

Lycoperdales

Lycoperdaceae

- Clavatia gigantea* (Batsch ex Pers.) Lloyd (1,2)
- Lycoperdon perlatum* Pers. (1,2)

Geastraceae

- Geastrum quadrifidum* Pers. (2)
Geastrum triplex Jungh. (3)

Tulostomatales

Calostomaceae

- Calostoma ravenelii* (Berk.) Masee (4)

Sclerodermatales

Sclerodermataceae

- Scleroderma bovista* Fr. (3,4)
Scleroderma geaster Fr. (3,4)
Pisolithus tinctorius Pers. (4)

Nidulariales

Nidulariaceae

- Cyathus striatus* Pers. (3,4)

Phallales

Phallaceae

- Mutinus caninus* (Pers.) Fr. (2)

REFERENCES

- Atkinson, G. F. 1897. Some fungi from Alabama. Bull. Cornell Univ. 3: 1-50.
- Dennis, R. W. G. 1968. British Ascomycetes. Cramer, Lehre.
- Mohr, C. 1901. Plant Life in Alabama. Brown Printing Co., Montgomery.
- Singer, R. 1962. The Agaricales in Modern Taxonomy. Cramer, Weinheim.
- Underwood, L. M. and F. S. Earle. Preliminary list of the known species of Alabama fungi. Bull. Ala. Agric. Exp. Sta. 80: 127-283.

INDEX

Absolute value and inequalities	143
Acardius acephalus human fetus, an	62
Addison, Mark K.	170
Adolescent hypertension, a longitudinal examination of factors related to	168
Adrian, John L.	152
Agricultural borrower characteristics, objective credit scoring--an analysis of	149
Agricultural impact of general development programs, an input model for assaying	153
Alabama coals, some chemical variations with rank for certain	129
Alabama red-bellied turtle, <i>Pseudemys alabamensis</i> , nesting habits of the	113
Alford, W. L.	140
Algae from northwest Alabama, some interesting	107
Allen, Laura H.	141, 142
Ammonium sulfate and urea on the growth of five species of algae isolated from lowland rice cultures, effects of	106
Amorphous silicon, electrical properties of	142
Amphetamine and caffeine on fluid volume intake in rats exhibiting schedule-induced polydipsia, the effects of	170
Analysis of urban growth: the case of Tuscaloosa, Alabama, 1938-1978, the use of sequential aerial photography in the	139
Andreoli, Kathleen G.	165
Anthropology and the new archaeology	176
Anthropology in West Bengal India, applied	177
Aramburu, Juan C.	143
Architectural zoning, a small city's experience with	138
<i>Armadillidium vulgare</i> (Latreille), ⁶⁵ Zn excretion as an indirect measurement of Q ₁₀ in the isopod	27
Atkinson, W.	145
Atrazine levels necessary to adversely affect aquatic plants in Chesapeake Bay	105
Audio tutorial modules for an introductory biology course, preparing. Azalea culture in northeast Alabama	108
Ball, Mary U.	116
Baltz, Timothy	106
Barnett, Wayne S.	131
Barrett, Michael R.	106
Baucom, Thomas F.	137
Bauman, James L.	172
Beaton, John M.	166, 167, 170
Becker, Gayle	168

Index

Beet armyworm, larval development and mortality in the	116
Bell factory: early pride of Huntsville	155
Bentley, Hersche P., Jr.	159
Benzene, the reaction of atomic carbon with	125
Benzimidazole and benzotriazole alkylations, phase- transfer catalysis of	125
Bertsch, Wolfgang	125, 127
Betacyanin chemical properties and distribution in the pokeberry (<i>Phytolacca americana</i>)	106
Beta spectroscopy for 89-90 strontium, development of	119
Biesiada, K. A.	125
Bivalve mollusks of the Buttahatchie River, Alabama and Mississippi	109
Blocking paradigm, effects of depletion of forebrain norepinephrine on performance in the	161
Box-Jenkins method for parameter estimation, on the	172
Bradley, James T.	111, 112
Bradley, Jeffrey A.	135
"Brookwood coal group," Brookwood, Alabama, petrography and lithology of the	132
Brownian motion in Banach spaces, on delayed averages of	143
Buckner, Ellen B.	169
Burkett, Dale	125
Business climate in Alabama: a comparison with other states, the	148
Butler, Michael	148
Cain, John L.	174
Campbell, O. A.	108
Campbell, P. Samuel	115
<i>Candida utilis</i> : kinetic and chemical studies, the active center of invertase from	126
Carbonate rocks, foundation problems in soils derived from	128
Cardiac muscle mechanics, exclusion of the effects of damaged ends in the study of isolated	171
Carmichael, Emmett B.	160
Caudle, Anita	162
Causey, Ann Sessler	1
Causey, Lynn	138
Cesium dimer, analysis of absorption and bound-free fluorescence in	118
Chan, Victor.	104
Chang, Mou-Hsiung	143
Chao, Shao-Hua	145
Chapman, Roger M.	131
Chase, David W.	176
Chastain, E. D.	153
Chastain, Marian F.	153
Chemistry at old LaGrange, Alabama's first college Chickamauga, the battle of	121 157
Chloramphenicol resistance from <i>E. coli</i> to <i>Proteus vulgaris</i> , transfer of	105
Christenberry, D.	47
Clark, Eloise	168

Index

Cobb, H. C.	140
Cochis, Thomas	106, 107
Conary, Jon T.	157
Conditioned taste aversions, the effects of monoamine uptake inhibitors on	165
Connolly, Paul	123
Cosmic rays with microcomputers, counting	146
<i>Cotinus obovatus</i> Raf. (Anacardiaceae) in Alabama, some notes on the distribution of	107
Covariance analysis in the study of economic growth patterns in two Alabama SMSAS, a use of	147
Coyote and red wolf in Alabama, status of	220
Cranford, Norman Bayne	131
Creel, R. M.	115
Cubic spline interpolation applied to missile trajectory generation	172
Current, William L.	108, 116
Darling, Charles M.	123
Davis, D. E.	105
Davis, Mark S.	110
Davis, William B.	158
Dawsey, Cyrus B.	137
Dawson, Ralph, Jr.	161, 166
De Vall, Wilbur B.	136
DeVault, William	126
Diachronic development of English kinship terminology, the 1,6-Diaminoalditol using TBOMS ethers, synthesis of	177
Dillard, James W.	122
Diplomatic relations between England and the dominions of Charles I and V, 1525-1535	119
<i>Diriofilaria immitis</i> : serological response of beagles throughout the course of infection	195
Distribution systems, a look at alternative product	116
Division of social science, N.E. Ala. St. Jr. Col.	211
Dixon, Mark D.	156
Dixon, S. J.	172
Donahue, Thomas D.	164
Donald, T. C.	161
Dose distributions from an intrauterine applicator	171
Doubly stochastic matrices, geometric properties of	145
Douglas, Sandra	144
Dusi, Julian L.	148
Dwarf salamander, <i>Manacus quadridigitatus</i> , testicular cycle and spermathecal anatomy of the	220
Dycus, Donald L.	114
Dynamic gyro model, performance of a	111
<i>Echiniscus virginicus</i> Riggin (Tardigrada) with notes on life history, range, and geographic variation, redescription of	175
Economic impact of the University of North Alabama on Lauderdale and Colbert counties, 1978, an	47
Education in the health science, competency based	148
Eggers, M.	168
	126

Index

Eiland, Ferrin W., II	114
Elam, David L.	123
Electricity, the analysis of the effect of conservations on the demand for	146
Elementary dimensional analysis into middle school science, introducing	154
Eley, Michael H.	115
EMG biofeedback muscle relaxation training and generalization of training effects, effects of anxiety on	164
Employment profiles of Alabama counties	137
Endangered, threatened, and special concern plants of Alabama	1
Environmental parameters as shown by some solitary corals, changes in	130
<i>Eperythrozoon suis</i> infection in swine: a case history	115
Essenwanger, Oskar	138
Ezzell, Jesse	126
Faculty research at a small college or university?	121
Farmers 1976, information needs and sources of Alabama	149
Faust, R. Kyle	105
Fischer 344 rats, absence of altered liver β -galactosidase in aging	171
Fishes of Cypress Creek, Wayne County, Tennessee, Lauderdale County, Alabama, the	118
Fleming, Mary Louise	168
Flinch-jump test in rats, the effects of various hormones on the	170
Flintknapping site in southeastern Alabama, a	176
Flippo, Ronnie G.	98
Flood delta Thanatocoenose, Eutaw formation, Montgomery County, Alabama, description of a	129
Flower and pod abscission of soybeans, <i>Glycine max</i> (L.) Merr., the effect of a cytokinin on	110
Fluorescence of mixtures of He, Kr, Xe, NF ₃ and UF ₆	140
Folsom, Michael W.	110
Ford, Jonathan	106, 126
Fornaro, Robert J.	177
Forney, D. R.	105
Fossil molluscs, detection of fluorescence in	131
Foster, L. M.	144
Foster, Thomas H.	150
Fouts, James A.	127
Francis, K. T.	163
Frazer, John M.	104
Free, W. J.	147, 151
Freeman, John D.	1, 70
French, Thomas W.	220
Fromhold, A. T., Jr.	141
<i>Fundulus grandis</i> collected from a national estuary and brackish water ponds, a comparison of the annual cycle of reproduction in	113
Fungi of Alabama. VIII.	225
Furman, W. L.	143

Index

GA-7 on the growth of a desmid, preliminary investigation of the effects of	104
Gaiser, J. E.	140
Gardemann, Joachim P.	167
Gasohol from newspapers: a survey	122
Gastaldo, Robert A.	132
Gay, Marjorie W.	175
Genetically obese mice, effects of 2-deoxyglucose on food intake in	162
Geographic literacy among university freshmen	136
Geography curriculum changes in Alabama colleges, 1957-1977	136
Geography's role in Alabama education	135
Germanium detector, efficiency calibration of a	142
Gibson, Peter M.	144
Giles, Jack, Jr.	144
Glass capillary columns, deactivation of	127
Glass capillary columns, new developments in the surface modification of	125
<i>Glomerella</i> leaf spot of apple, effect of temperature on development of	117
Gooch, Charles	118
Grafted polynomial to estimate crop response surfaces for agricultural lime, using the	147
Gray, D. J.	225
Greely, M. S.	113
Greenberg, Stan	159
Griner, Gary M.	173
Hall, Harry H.	147
Hardy, William E., Jr.	149, 152, 211
Harper, James D.	114
Harper, R. C.	140
Harrison, G. L.	149, 150
Harvey, J. T.	119
Haynes, Robert R.	1
Hefner, L. L.	171
Helminth parasites of the gray fox (<i>Urocyon cinereoargenteus</i>) in Alabama and Georgia	109
Helms, Billy P.	146
Henderson, H. A.	153
Heparin N-sulfate sulfatase, purification and properties of	157
Herpes simplex virus infections, identification of immune components which augment chemotherapy of	158
Herpetofauna of the Limesink region of southeastern Alabama, a survey of the	116
Hill, W. E.	124
Ho, S. M.	124
Hobbs, Billy B.	119, 120
Hoesterey, Barbara L.	123
Holmes, Ann E.	134
Holmes, Jack D. L.	156
Hopping transport of charged particles through solids and biological membranes, difference equation solutions for	141
Hornbeak, H. H.	158

Index

Housing quality for blacks in Alabama, the effects of the 1960's on	138
Huang, D. H.	145
Hubert, Wayne A.	87
Hudson, C. G.	140, 141
Humaideh, Issam H.	166
Humate occurrence in Alabama and Florida	131
Huscher, Harold A.	176
Hutcheson, James B.	62
Huttlinger, Frank D.	139
Hutto, Anita	70
Hydration of football players during early fall practice in Alabama, on the choice of fluid for the	163
Hypertensive patients, compliance behavior in	165
Hyperthermia, heat transfer in	145
Idiopathis scoliosis and the menstrual onset--are they related	164
Instructions to authors	96
Interferograms, computer aided analysis of	142
Iodide metabolism, effects of 2-selenouracils on	160
Iodine in milk, determination of stable	119
Irby, Don	146
Isbell, Raymond E.	121, 122
Ischemia, regional vulnerability of the brain to	162
Jeane, D. G.	136
Johnson, Howard G.	135
Johnson, Louise E.	164
Jolly, Alexander C.	172
Jones, Thomas R.	116
Kaenel, Kim Von	157
Kallsen, Thomas J.	139
Kanipe, Larry G.	119, 120
Katz, William M.	132
Keynote address	98
Kiely, Donald E.	121, 122
Kilgore, Melvin V.	123
Klimasewski, Ted	138
Koch, Arthur R.	107
Koch, C. T.	125
Krishna, N. R.	145
Lacy, A. Wayne	146, 148
Lamb, Trip	110
Landers, Kenneth E.	106, 107
Lane, C. Patrick	170
Lane, Roger S.	171
Latham, A. J.	117
Lauhachinda, Nitaya	27
Lead and 210-polonium in the environment, determination of 210-	119
Legal problems of the low income population in northwest Alabama	135
Leonard, Maceo	151
Ligand ethylene bis(oxyethylene)bid(diphenylphosphine), nickel II complexes of the	124

Index

Lime vendors in north Alabama, profile of	151
Lin, Nora C. T.	145
Lindsay, Raymond H.	160, 161
Linton, Roger C.	157
Lipids associated with soybean seed development, changes in	35
Literary image of the far east in the early nineteenth century, the	155
Livant, P.	126
Lorden, Joan F.	161, 162, 165, 166
MacGregor, Robert, III	112, 113
Malatino, Anthony M.	134
Mancil, Mary E.	146
Manley, Reeser C.	35
Marcoux, Frank W.	162
Mareno, M. J.	142
Marks, Henry S.	156
Marks, Marsha Kass	155
Martin, Neil R.	150
Mason, W. H.	27, 47, 108
Mathematicians and relativity	143
Mathias, Lon J.	125
McCord, Wallace A.	129
Meany, David B.	113
Melius, Paul	123
Melvin, Emily	136
Metallurgical coal resources of Alabama, known	173
Miller, Margaret	104
Millican, C. Leigh	170
Minutes of annual business meeting	178
Mitchell, Vester P., Jr.	87
Mixed function oxidase activity in the rat, mullet, and killifish, a comparative study of induction of	123
Mobile in 1858, some aspects of	154
Mobile's great hurricane of 1819	156
Moeller, M. B.	118
Molybdenum-rich gossans, mineralogy and chemistry of	133
Monahan, Michael	140
Monosodium glutamate in mice, behavioral effects of postnatal injections of	166
Moore, Karen M.	120
Morgan-Jones, G.	225
Morse, Carol A.	155, 195
Murdock, Larry R.	175
Murdock, Marianne	168
Murphree, Quincy	140
Murphy, Vayden L., Jr.	211
Murray, Barbara B.	115
Musgrove Creek gas field, central Fayette County, Alabama	131
Myers, W. D.	163
<i>Myxosoma funduli</i> Kudo (Myxosporida) in <i>Fundulus kansae</i> : ultrastructure of the plasmodium wall and sporogenesis	108
N-halosilazanes containing phosphorous fluorides	124
N-methyl acetamide, MINDO/3 calculations on isomers of	123

Index

Nanosecond nuclear lifetimes, experimental determination of . . .	140
Navia, Juan L.	122
Neely, W. C.	123
$^{58}\text{Ni}(n,d+n,pn+n,np)^{57}\text{Co}$ reaction cross section at 14 MeV	141
Nicolaro, Mary-Lou	112
Nitrogen heterocycles from sugar acid diamides	121
N,N-dimethyltryptamine in human cerebrospinal fluid (CSF) and rat brain using gas chromatography-mass spectrometry, a determination of	167
No-till and archaeological sites	175
Nuclear Overhauser effect, solution conformation of peptides by	145
Nunn, William B.	165
Nursing diagnosis and intervention, poor initiation of lactation:	169
Oaks, John E.	158
Ovarian development of smallmouth bass in Pickwick Reservoir . .	87
Ovarian responses to ovine LH in gulf killifish (<i>Fundulus grandis</i>), daily rhythm in the	112
Pastrick, Harold L.	173, 174, 186
Patterson, Tommy H.	139
<i>Pecopteris</i> Brongniart, morphological plasticity in the upper carboniferous form genus	132
Pelleymounter, Mary Ann	161
Personnel dosimetry performance testing study, an overview of the	141
Peterson, Curt M.	110
Peterson, Raymond D. A.	159
Petranka, James W.	70
Petrology of the Farmville gneiss, northwestern Lee County, Alabama	127
Phenacemide in tablets, GLC determination of	123
Pheophytin, studies on the copper complex of	120
Photoelectron spectroscopy as a tool in gas phase conformational analysis, lone pair-lone pair interaction in a bicyclic diamine.	126
Pitcher plant moth (<i>Exyra</i> : Noctuidae), overwintering in three species of	109
Plane of polarization: a classroom demonstration of a latent capability, naked eye determination of the	140
Plankton transport downstream through multipurpose flow- through reservoirs, method for determining	111
Policy design, the engineering of	174
Polyphenol oxidase from potatoes, effect of saccharides on	104
Poultry industry in the Tarcog area, the infra-structure needed to support the	151
Powers, R. P.	120
Prasanna, H. R.	171
Precision neutron dosimetry with CF-252	140
Precision stabilization, IBSSU: a novel approach to	172
Premarital sex, social determinants of attitudes toward	157
Propagation through clear air, submillimeter	143
Pupal populations of <i>Malacosoma disstria</i> in Alabama, mortality factors influencing	114

Index

Quasilinear hyperbolic systems, linearized approximations of . . .	144
Raines, William L.	119
<i>Rana grilio</i> in south Georgia, food habits of the pig frog	110
<i>Rana sylvatica</i> (Amphibia: Anura: Ranidae) in Alabama, preliminary observation on the wood frog	110
Randleman, C. Duane	117
Rat ovarian tumors, inhibitory effects of selenium on induced . .	117
Rebert, Richard Ross	159
Reddington, Mary C.	112
Reeves, D. N.	171
Reid, W. J.	140
Reiff, T. V.	142
Residential attitudes toward a proposed highway route	137
Reynolds, George W.	142
Rheams, Lawrence J.	128
Richmond, Charles W.	122
Rickert, Edward J.	161
Rifle beetles (<i>Coleoptera</i> : Elmidae) of Alabama, the	114
Riggsby, Dutchie S.	154
Riggsby, Ernest D.	154
Roberts, K.	126
Rodén, Lennart	157
Rogers, Elton D.	109
Rottman, Joey S.	105
Rural health care project for migrants in the Sand Mountain area of northeast Alabama, a	168
Rural land market in major agricultural areas of Alabama, the . .	152
Rymal, Debbie E.	109
Sakas, Peter S.	116
Sax, Steven R.	139
Schrader, Ed L.	133
Schrimsher, Jeffrey L.	115
Sedimentation affecting the natural life of a lake in the Warrior River basin within Tuscaloosa County, Alabama . . .	134
Semk, Kathy	121
Serotonin localization by fluorescent techniques in tissues of normotensive and hypertensive rats	159
Sex steroid hormones upon cardiac and other tissues in adult castrated or ovariectomized rats, acute effects of	115
Sharpe, Michael R.	159
Shell, William B.	168
Sheridan, Richard C.	121
Shevlin, P. B.	125
Shipman, Jerry R.	147
Short, John W.	1
Shotts, Reynold Q.	129, 173
Shoults, Margaret C.	125
Shrubs in north Alabama, uncommon	106
Similarity measures for time series data	173
Simulation, on the economics of	186
Sirmans, Susan	123
Sisler, Peter	174
Slemmer, Heather J.	153

Index

Sloan, Rebecca	169
Smith, Vernon	147
Snell, Joni M.	117
Solar energy heating in a cloudy climate	138
Spanish exploration and conquest in the upper Gulf of Mexico, 1512-1561, the second phase of	156
Stallings, J. L.	149
Stark, Elizabeth J.	114
Stephenson, Susan R.	138
Stewart, Dorothy Anne	143
Stewart, W. S.	151
Stewart, William	148
Stock, Carl W.	130
Stone Hill massive sulfide copper deposit: Cleburne and Randolph Counties, Alabama, geology and geochemistry of the	128
Stoner, David	135
Street, Donald R.	146
Streptozotocin diabetic rats, alterations of hepatic microsomal drug metabolism in	161
Stromatoporoidea within the porifera, relationships of the . . .	130
Stromatoporoids in a lower Devonian (Keyser formation) bioherm, Mustoe, Highland County, Virginia, distribution of	134
Strong, William R.	135
Substantia-nigral lesions, the effects of various neutral amino acids on d-amphetamine induced circling in rats with	166
Summer flora of Horseshoe Bend National Military Park, Alabama	70
Superfigures replicating with polar symmetry	144
Suspension fertilizers--the response of young Tennessee Valley farmers to labor and capital constraints?	150
Sutherland, Donald W.	186
T-lymphocytes, quantitation of	159
Take stock!--a misleading word	136
Tatum, W. M.	113
Taylor, J. G.	124
Taylor, John A.	158
Tellinghuisen, Joel	118
Terminally guided missile--soft and hard constraints, on the realization of an optimal control law for a	174
Thomas, James L.	160
Thompson, Anita	127
Thompson, Jerry	157
Thorn, Cecelia Jean	155
Tornado force estimation, a rationale for	142
Trauth, Stanley E.	114
Trimble, W. C.	113
Tudor-Hapsburg relations 1525-1535	155
Turner, Kathleen D.	177
Uranium and 226-radium by gamma-ray spectroscopy	120
Urban forestry plan for Alabama communities, an	139

Index

U.S. domestic vicious circle problems, keys to	153
Vallery, J. F.	146
Vehicle routing and scheduling systems, economic efficiency of	152
Vigee, Gerald S.	120
Vitamin C, multiple functions and properties of	160
Walker, A. A.	171
Ward, James W.	62
Waters, Laura A.	130
Weaver, David C.	136
Weed, John B.	149
Weete, John D.	35
Werkheiser, A. H.	142
Wesson, Kenneth R.	154
Wettermark, M.	158
Whetstone, R. D.	106, 107
Whittington, Dave	128
Widowed and retired persons in Alabama, an analysis of electricity demand by	146
Williams, G. Bruce	172
Williams, John	140
Williams, Ronald J.	150
Wilson, Harold J.	115
Woodward, R. O.	153
Worley, S. D.	123, 126
Yokley, Paul, Jr.	109
Yolk proteins in developing oocytes of <i>Acheta domesticus</i>	112
Yolk protein synthesis in ovariectomized house crickets	111
York, R. J.	174

NOTES

NOTES

THE JOURNAL
OF THE
ALABAMA ACADEMY
OF SCIENCE

AFFILIATED WITH THE
AMERICAN ASSOCIATION FOR THE
ADVANCEMENT OF SCIENCE

VOLUME 51

JANUARY, 1980

NO. 1

EDITOR:

W. H. Mason, General Biology, Auburn University, Auburn, AL 36830

ARCHIVIST:

R. G. Eaves, Department of History, Auburn University, Auburn AL 36830

EDITORIAL BOARD:

R. T. Gudauskas, Chairman, Department of Botany and Microbiology,
Auburn University, Auburn, AL 36830

E. A. Curl, Department of Botany and Microbiology, Auburn University,
Auburn, AL 36830

W. W. Paulder, Department of Chemistry, University of Alabama, Uni-
versity, AL 35486

ADVISORY BOARD:

W. L. Alford, Auburn University

Charles Baugh, Univ. South Alabama

G. F. Brockman, Univ. Ala., B'ham

R. J. Fornaro, Univ. South Alabama

A. Wayne Lacy, Auburn Univ., Mtgy.

Walker H. Land, Jr., IBM

H. S. Marks, N. E. St. Jr. Col.

M. Miller, Univ. South Alabama

W. W. Paulder, UA, Tuscaloosa

Dan Whitson, Decatur

E. M. Wilson, Univ. South Alabama

The Journal is the official publication of the Alabama Academy of Science, and is indexed in Biological Abstracts, Chemical Abstracts, America: History and Life, and Historical Abstracts.

Publication and Subscription Policies

Submission of Manuscripts. Submit all manuscripts and pertinent correspondence to the EDITOR. Each manuscript will receive two simultaneous reviews. For style details, follow Instruction to Authors, *J. Ala. Acad. Sci.* 50:96-97, 1979.

Reprints: Requests for reprints must be addressed to authors.

Subscriptions and Journal Exchanges: Address all correspondence to the CHAIRMAN OF THE EDITORIAL BOARD.

Advertising, News Releases: Advertisements and news releases will not be published in the Journal.

CONTENTS

ARTICLES

- The Demand for Electricity by Widows and Retired
Persons in Alabama: An Income Segmented Approach
A. Wayne Lacy, Donald R. Street, and Don Irby 1
- Power Plant Recirculation and Entrainment Impact:
A Solution for Constant Recirculation and Once-
Through Mortality Rates
William E. Cooper, Jr. 16
- Interaction of Noise Stress with Adrenocortical
Responsiveness to *in vivo* and *in vitro* ACTH
Stimulation
W. F. Johnson, J. F. Pritchett, D. N. Marple,
M. L. Till, and W. L. Harper 20
- Fungi of Alabama. IX. Dematiaceous Hyphomycetes
G. Morgan-Jones 30
- Additional Distributional Records of the Prairie Vole
(*Microtus ochrogaster*) from Northern Alabama
Douglas S. Allen and Julian L. Dusi 45
- Determination of Distance to be Moved from Experiment
to Experiment When Exploring a Response Surface
G. S. Hines and J. N. Hool 47

THE DEMAND FOR ELECTRICITY BY WIDOWS AND RETIRED PERSONS
IN ALABAMA: AN INCOME SEGMENTED APPROACH¹

A. Wayne Lacy

*Department of Economics, Management, and Marketing
Auburn University at Montgomery
Montgomery, AL 36117*

Donald R. Street and Don Irby

*Department of Economics
Auburn University
Auburn, AL 36830*

INTRODUCTION

The energy shortage, accompanied by rising prices of energy-dependent goods and services, has prompted considerable activity to determine its effects on different groups in the economy. Special concern has been expressed regarding widows and retired persons who may spend large proportions of their income for utilities. The purpose of this study was to analyze, by income levels, the demand for electricity by widows and retired persons in the Alabama Power Company service area. The study was designed to determine the responsiveness of this customer group to several variables, especially price changes.

The present study represents an extension of an income-segmented demand model by Lacy and Street [4] (hereafter referred to as the LS study) for over 1,400 individual customers for a five and one-half year time series. The model and testing procedures were generally the same in both studies. The only differences, explained below, involved the methods of categorizing the individuals by income class.

The sample for this study was extracted from the extensive random sample (about 25,000 customers) of the general population described in the LS study. Census tracts in combination with meter-reading routes and city directories were used to identify appropriate income categories for individual customers in three cities of the Alabama Power Company service areas of Birmingham, Mobile, and Montgomery. The census tract map location included only those persons who maintained the same residence and meter for a period of five and one-half years.

Customers were assigned to income classes on the basis of (1) income averages by census tracts and (2) average housing value by census block within the tract. In general, the income class assigned to each customer was either (1) the mean income for the tract or, (2) the mean income of the income class above or below the mean income of the census block

¹Manuscript received 29 March 1979; accepted 29 November 1979.

Demand for Electricity

location. The method involved a relative comparison of housing values by census block with the income averages of the census tracts. If the housing values were relatively low, individuals were decreased by an income class and if housing values were relatively high, the next higher class was used. This method of income assignment is not as precise as the LS method reported in this journal earlier [3], since an occupation variable was not applicable to the sample subjects. The sample of 528 customers is shown by income class and group in Table 1.

Table 1. Income classes used in the study by number in customer group.

Income Class	Income Range	Customer Group			Income Class Totals
		Widow	Widow-Retired	Retired	
I	0 - 2,999	6	0	11	17
II	3,000 - 4,999	21	2	18	41
III	5,000 - 7,499	21	4	46	71
IV	7,500 - 9,999	37	11	87	135
V	10,000 - 14,999	23	13	110	146
VI	15,000 - 19,999	8	5	47	60
VII	20,000 - 24,999	4	8	15	27
VIII	25,000 and over	6	1	24	31
	Totals	126	44	358	528

Retired persons and widows may live in a given area of income levels more as a result of wealth accumulated than as a result of their current income level. Consequently, this study may be a reflection of past earning levels rather than current levels. This loss of precision was the primary reason for excluding the widow and retired category from the LS study.

The possibility exists that some urban bias may be present in this study. However, there is no a priori evidence that rural dwellers of a certain income level would behave substantially different from urban dwellers. Furthermore, from the electric utility standpoint and from the standpoint of policy decisions regarding the company, this bias would tend to be small since the bulk of the company's residential customers are in urban areas.

ANALYSIS OF RAW DATA ON ELECTRICITY USE BY WIDOWS AND RETIRED PERSONS

The electricity consumption of the widowed and/or retired customers is summarized by income level in Table 2 for the first year of the study, 1971, and for the last year of complete data for the study, 1975.

As shown in Table 2, average use by the combined customer group categories generally increased as income increased. The most notable exception was for income change from class VI to class VII. The average KWH consumed for class VI in both 1971 and 1975 exceeded the average KWH used by class VII. In comparing the annual consumption of these two samples, retired persons consumed, on the average, more electricity than widows. This result was expected since widows would tend to have a smaller consuming household than retired persons.

The widow-retired group, which consumed less than the income class average, increased from 8.3 percent of the sample for income class VI to 29.6 percent of the sample class VII. The retired group, which consumed a greater amount than the average for the customer group for the class, decreased from 78.4 percent of the observations in income class VI to 55.6 percent in income class VII. This shift in proportions within the income classes adequately explains the consumption discrepancy between income classes VI and VII. The proportion of widows remained approximately the same for the two classes in question.

Comparing 1971 and 1975, the tendency was for consumption to increase in all but the first of the four lowest income classes; consumption between the two years decreased for the remainder of the income groups except for class VIII. Income class VIII had a 2.9 percent increase between the two years, but would have shown a net decrease if the single extreme value (70.6 percent increase) for the widow-retired category had not been included (See Table 3). This single aberration was most likely due to some unmeasured cause, such as non-occupancy in 1971.

The pattern was more complex when examined by customer group category. Consumption by widows increased in class I and II but then decreased for the other income classes with a tendency toward an increasing percentage of decrease as income increased. Retire persons, however, decreased consumption in classes I and II, but exhibited no general pattern as income increased. The explanation for this behavior is not immediately clear. The increased use by the widow sample in income classes I and II could have resulted from growing appliance saturation for low-income customers that kept their use rising while higher income customers with a high saturation of appliances attempted to conserve energy. This effect may not have applied to the older, retired couples who did not expect rising incomes and therefore did not purchase additional energy-consuming appliances.

When compared with the general population, [3] widows consumed significantly less at every income level and retired persons consumed less at every income level except the very lowest one. This result was not surprising since widowed and retired households usually have fewer members. Even with a lower consumption base, widows had greater percentage reductions in electricity use between 1971 and 1975 than the general population.

Weather factors did not play a major role between the two years of this sample. There was a 6.4 percent decrease in heating degree days and a 6 percent increase in cooling degree days during the time period

Demand for Electricity

Table 2. Average annual KWH consumption by income class and customer group for 1971 and 1975.

Income Class	Customer Group	Percent of Customers	Average Annual KWH 1971	Average Annual KWH 1975	Percent Change
I	Total Class		4,250	3,824	-10.0
	Widow	35.3	2,667	3,000	+12.5
	Widow-Retired	0	-----	-----	-----
	Retired	64.7	5,200	4,272	-17.8
II	Total Class		4,100	4,414	+ 7.7
	Widow	51.2	3,476	4,047	+16.4
	Widow-Retired*	4.9	5,000	7,000	+40.0
	Retired	43.9	4,176	4,111	- 1.6
III	Total Class		5,310	5,914	+11.4
	Widow	29.6	4,619	4,400	- 4.7
	Widow-Retired	5.6	7,500	7,500	0
	Retired	64.8	5,435	6,434	+18.4
IV	Total Class		7,385	7,889	+ 6.8
	Widow	27.4	7,108	6,838	- 3.8
	Widow-Retired	8.1	4,091	5,000	+22.2
	Retired	64.5	8,356	8,701	+ 4.1
V	Total Class		9,635	9,438	- 2.0
	Widow	15.8	10,043	9,435	- 6.1
	Widow-Retired	8.9	7,615	6,692	-12.1
	Retired	75.3	9,786	9,764	- .02
VI	Total Class		11,416	11,200	- 1.9
	Widow	13.3	10,750	9,750	- 9.3
	Widow-Retired	8.3	6,600	8,200	+24.2
	Retired	78.4	12,043	11,766	- 2.3
VII	Total Class		10,259	9,963	- 2.9
	Widow	14.8	6,000	5,000	-16.7
	Widow-Retired	29.6	9,000	8,250	- 8.3
	Retired	55.6	12,067	12,200	+ 1.1
VIII	Total Class		13,129	13,516	+ 2.9
	Widow	19.4	15,667	14,333	- 8.5
	Widow-Retired	3.2	17,000	29,000	+70.6
	Retired	77.4	12,333	16,666	+ 2.7

* One extreme value eliminated.

studied. Weather alone would appear to have favored a slight increase in consumption between the two years.

THE MODEL AND METHODOLOGY

Ordinary least squares regression was used for analysis. The basic model utilized was:

$$\ln Q = b_0 + b_1 \ln P_e + b_2 \ln \Delta Q_{t-1} + b_3 \ln D + b_4 \ln T + b_5 \ln W$$

where: Q = monthly KWH use per customer; P_e = marginal price of electricity in real terms; ΔQ_{t-1} = the difference in KWH use between period $(t-2)$ and period $(t-1)$ (i.e., between quantities for one and two months prior to the current one); D = patriotism dummy; T = trend variable; and W = weather variable.

An income variable was not included in the equation since income data on a monthly basis for each customer in the sample were not available. Even if a sufficiently discriminating income variable could be found, it might fail to pick up the full impact of income upon the consumption of electricity. One might expect the effect of increased income upon electricity consumption to be "lumpy," that is, to show its effect in spurts as higher incomes allow the purchase of new appliances and in its ultimate form, the purchase of larger, more energy intensive homes. This sample, however, included only customers with uninterrupted service at the same residence for five and one-half years.

Also excluded from this model were two variables often found in aggregate model studies: the price of natural gas and a measure of economic activity in the service area. Economic theory states that the demand for a particular good is affected by changes in the price of substitutes for that good. Admittedly, overall demand for electricity is affected by changes in the relative price of natural gas. However, individual families can make little substitution without substantial investments in equipment. These changes are likely to be a small fraction of the sample during any five and one-half year period. Therefore, this variable was not included in the time series model.

Economic activity variables attempt to measure the extent of unemployment, whether of industrial capacity or of labor, in the economy; they cannot show periods of unemployment for an individual wage earner. Such a variable, however, may measure to some degree the psychological or "optimism" level of the consuming population and to that extent account for some of the demand for electricity. For individuals, the results would not be expected to be significant unless the employment status of each customer tested was known. Also, many of the customers in the sample were on basically fixed incomes. Therefore, a measure of economic activity was not included in the demand model.

The price variable used was the marginal price of each customer adjusted for inflation by the consumer price index. Marginal price in a decreasing block rate structure is the price per KWH applied to the last block that the customer's monthly consumption attains. In this

Demand for Electricity

way, a natural logarithm of the price variable allowed the regression coefficients to measure directly the percentage response of quantity consumed to percentage changes in price (price elasticity). The fuel adjustment surcharge was included in the price.

The next independent variable, ΔQ_{t-1} , was an attempt to measure customer reaction to higher electric bills. Earlier studies have indicated that consumers are more aware of increases in the total bill than of changes in the price [5]. The consumer who reduces consumption in the present period (t) in response to a higher bill is actually reacting to a bill for consumption levels between the two preceding periods (t-2) and (t-1); the construction of this variable incorporates this response. A negative elasticity coefficient was expected for ΔQ_{t-1} .

The third variable (D) was a dummy developed to measure public response to Presidential appeals for energy conservation. A weight of zero was given before November 1973, a weight of two was given for November as a partial month (since the first strong presidential appeal came near mid-month) and a weight of three was given for each of the next four months. As the visible need for conservation was reduced by the end of the Arab oil embargo, expectations were that the conservation response would also be reduced. The dummy value was reduced accordingly to two for April and the next two months and thereafter to a value of one as old consumption patterns began to reemerge.

The trend variable (T) was included in the model to measure changes in consumption patterns not accounted for by other variables. The value of the trend variable would thus be affected by growth in income that translated into increased electricity consumption. This variable would also reflect secular changes in electricity use generated by changes in life styles. A positive coefficient was expected for this variable.

The final variable used in the model was the weather variable (W). Consumption of electricity obviously could be expected to increase in periods of immoderate weather as families with electric heat and air conditioning heated and cooled their homes. Because the data did not reflect the presence or absence of air conditioning and electric heating, four regressions, each using a different version of the weather variable, were estimated for every member of the 528 customer sample. These versions were (a) cooling degree days only, (b) heating degree days only, (c) heating plus cooling degree days, and (d), (a) and (c) above separately.

The computation of the weather variable involved taking the weather patterns of Birmingham, Mobile, and Montgomery and adjusting each to reflect the actual days billed for each customer. Twenty-one different billing dates required the computation of 21 weather cycles of 66 months for each city, giving a total of 63 patterns.

TIME SERIES RESULTS

Price Elasticity

The results of the time series regression analysis are presented in Tables 3 through 7. The sample of widows and retired was expected to demonstrate a greater price elasticity than exhibited by the general population since they face greater budget constraints than the general population. Also it was expected that the price elasticities would decline as income increased. The price elasticity results are shown in Table 3.

The empirical results in Table 3 confirmed earlier findings [4] that the unweighted average price elasticity of demand declines as income increases up to income class VII. Values ranged from a high of -1.14 for the less than \$3,000 annual income class to a low of -.30 for income class VI, for \$15,000 to 20,000 per year. In all income classes, the combined sample exhibited higher elasticities than those of the corresponding income class for the general population [3]. Dispersion or variability of the elasticities also declines as income increases, as shown by the standard deviation of the elasticities for each group.

The standard deviations reported in Table 3 are not an average of the standard errors of the regression coefficients. Rather, these figures represent the single standard deviation or spread of the coefficients of price elasticity in each income class. Thus they do not relate to the statistical significance of the coefficients. Of the 528 customers analyzed, 84.7 percent displayed a price elasticity that was negative and significant at the ten percent level or better.

The exception to the pattern of declining elasticity as income rises was income class VII. Class VII is the second smallest of the sample sizes (only 27 observations), making it more susceptible to sampling error. However, the large jump in price elasticity for all customer classifications in this income group requires an examination of other factors. The price response by this income group may reflect the potential for decreased electricity usage proposed by Berman and Graubard [1]. Their study predicted higher negative price elasticities based upon the ability of higher income groups to reduce consumption due to the many uses they have for electricity. Income class VII may then reflect the willingness plus the ability necessary for a true price response. This group would tend to own more electric appliances whose use could be curtailed without seriously affecting the accustomed standard of living (the increase in the standard deviation for these classes indicates that not all of its members are responding to potential usage reduction stimuli).

Although income class VIII would possess the same ability to reduce consumption, the highest income group would not face the same degree of budgetary constraint to force them to do so. Thus income class VIII could show less price response than class VII but still greater than class VI. Although relatively "well-to-do," these two income classes are also more likely to be dependent upon fixed incomes than the general population and coupled with a greater potential for usage reduction, may

Demand for Electricity

Table 3. Summary of price elasticity results.

Income Class	Customer Classification	Average of Unweighted Price Elasticities		Standard Deviation of Price Elasticities in Each Class	Number of Customers
I	All Groups	-1.14		.89	17
	Widow	-1.20		1.15	6
	Widow-Retired	-----		----	0
	Retired	-1.12		.70	11
II	All Groups	- .86		.87	41
	Widow	- .82		.93	21
	Widow-Retired	- .93		1.01	2
	Retired	- .89		.83	18
III	All Groups	- .61		.69	71
	Widow	- .81		.84	21
	Widow-Retired	- .43		.50	4
	Retired	- .53		.60	46
IV	All Groups	- .59		.64	135
	Widow	- .57		.69	37
	Widow-Retired	- .63		.54	11
	Retired	- .54		.66	87
V	All Groups	- .51		.63	146
	Widow	- .62		.68	23
	Widow-Retired	- .30		.64	13
	Retired	- .55		.59	110
VI	All Groups	- .30		.46	60
	Widow	- .47		.58	8
	Widow-Retired	- .41		.46	5
	Retired	- .28		.43	47
VII	All Groups	- .74		.69	27
	Widow	- .77		.54	4
	Widow-Retired	- .75		.88	8
	Retired	- .74		.65	15
VIII	All Groups	- .38		.46	31
	Widow	- .35		.42	6
	Widow-Retired	- .03		----	1
	Retired	- .41		.47	24
Totals	All Groups	- .64			528
	Widow	- .70			126
	Widow-Retired	- .50			44
	Retired	- .63			358

show greater price response than lower income groups where reduced electricity use may mean a more significant reduction in the accustomed standard of living.

Lagged Change in Quantity Results

The variable ΔQ_{t-1} was used in an attempt to measure the consumer's reaction to an increased billing with negative response hypothesized. While 56.6 percent of the sample did respond negatively, the figure was lower than expected. A summary of the ΔQ_{t-1} elasticities by income class is given in Table 4 for the combined sample.

Although the ΔQ_{t-1} coefficients generally were statistically significant for a two tail test at the ten percent level, the results did not provide strong support for the use of the variable as a negative response to higher bills. The results tended to be positively or negatively significant with wide variability within each income class, as evidenced by the high values of the standard deviations for the coefficients of each class.

Table 4. Summary of ΔQ_{t-1} Elasticities by Income Group.

Income Class	Average of Unweighted ΔQ_{t-1} Elasticities	Standard Deviation of ΔQ_{t-1} Elasticities in Each Class	Percent ΔQ_{t-1} Negative ^C
I	.24	3.37	58.8
II	.03	7.42	45.5
III	.51 ^a	4.06	52.2
IV	.98 ^b	4.40	47.8
V	-.99	3.18	69.7
VI	-.69	3.72	66.2
VII	.84	5.17	42.3
VIII	-.13	3.52	51.6

^aExtreme value of 20.10 deleted yielding a coefficient of .77 and standard deviation of 5.80.

^bExtreme value of 36.10 deleted yielding a coefficient of 1.23 and standard deviation of 5.78.

^c56.6 percent of entire sample gave negative value for ΔQ_{t-1} .

A pattern to the results in Table 4 was not readily discernible. The four lowest income groups showed an average positive response to higher bills while three out of the four highest income groups (the exception being class VII) exhibited an average negative response. This finding would appear to contradict the inverse relationship between income and price elasticity noted earlier. The results of the lagged

Demand for Electricity

change in quantity variable would seem to indicate that other factors such as the seasonal use of electricity are measured in this variable.

A potentially useful analysis of the lagged change in quantity variable was to compare the signs of the price elasticity coefficient and ΔQ_{t-1} elasticity coefficient by income class. If the ΔQ_{t-1} elasticity is negative, the price response is strengthened; if it is positive, the response is diminished. If the price elasticity and the ΔQ_{t-1} elasticity are both positive, there is no price response captured in either variable.

Only two income classes, IV and VII, exhibited a net reduction in the price response due to the inclusion of ΔQ_{t-1} (8 percent and 15.4 percent respectively); for the other income classes, the price elasticity was enforced. The income classes which displayed the greatest support for a higher price elasticity were classes I, V and VI (17.6 percent, 35.2 percent, and 29.2 percent respectively). However, no consistent pattern emerged and any interpretation of these results must be viewed cautiously.

Table 4 also shows, by income class, the percent of ΔQ_{t-1} negative coefficients for the combined sample. No clear pattern by income class emerged. Only 47.3 percent of those earnings over \$20,000 responded in the present to higher past billings. Those reacting most to prior billings were income classes V and VI (69.7 percent and 66.2 percent respectively). The negative response by income class did not generally decline for widows and/or retired persons with an increase in income.

Patriotism Dummy

The use of individual billing data was essential to the investigation into the impact on electricity use of the presidential appeal for the conservation of energy in November 1973. An earlier 1975 aggregate study by Lacy and Street [2] found the patriotism dummy to be insignificant in most forms of the model tested. This was likely due to the aggregate problems associated with group samples: those members who show significant response are "washed out" in the aggregation of the data. The disaggregated study by income class of the individuals, however, showed that over half (58.5 percent) of those tested responded significantly at the ten percent level with 88.5 percent exhibiting a negative response.

Table 5 shows the results of the patriotism dummy for this study. A total 85.4 percent of the sample reduced their consumption of electricity in response to the presidential appeal; 55.1 percent exhibited a response significant at the 10 percent level or better, and 38.6 percent of these were significant at the 5 percent level.

Both the percent and significance of widows and retired persons responding to the conservation appeal generally increased with an increase in income. This does not mean that the higher income groups are more patriotic. The level of awareness of the severity of the energy situation at the time, the access to information and the ability to

Table 5. Results of "patriotism" dummy for the combined sample (all values in percentage).

Income Class	Negative and Significant at 5 Percent Level	Added Negative and Significant at 10 Percent Level	Negative and Significant at 10 Percent Level or Better	Negative and Not Significant at 10 Percent Level	Positive Relationship	Total Negative
I	35.3	5.9	41.2	41.2	17.6	82.4
II	34.1	6.8	40.9	38.6	20.5	79.5
III	37.5	8.3	45.8	33.3	20.8	79.2
IV	38.0	19.0	57.0	28.5	14.6	85.4
V	33.8	14.1	47.9	41.5	10.6	89.4
VI	43.1	10.8	53.8	26.2	20.0	80.0
VII	50.0	19.2	69.2	23.1	7.7	92.3
VIII	54.8	32.3	87.1	9.7	3.2	96.8
Totals	38.6	16.5	55.1	32.2	14.6	85.4

Demand for Electricity

reduce electricity consumption may all be expected to rise with income. Of the highest income class 96.8 percent decreased consumption, 87.1 percent of them significantly at the 10 percent level or better, due to the presidential appeal.

Apparently, the presidential appeal for conservation was a factor in the consumption of electricity for more than one-half of the sample. While a quantity effect interpretation is not possible with the dummy variable, the indication of customer response is an important finding.

Trend

The results of the trend variable are shown in Table 6. The percent of customers which exhibited a positive and significant trend (at the 5 percent level) tended to decrease as income increased.

There is a strong probability that these results can be traced to a relationship between appliance saturation levels and income growth. A growth in income for low income families is likely to lead to purchases of new electricity-using items, because of low saturation levels. High income groups, on the other hand, with high saturation of electricity-using appliances are not nearly as likely to buy new electricity-using items. The area where high income persons are most likely to increase electrical consumption is through purchase of a larger home. This possibility was omitted from the sample since no movements from one home to another took place within the sample group.

Weather

The results of the weather variable are summarized below. As incomes rose, the size of the coefficient and the percent significant tended to rise slightly. The size of the coefficients were relatively small; the largest percent of each income class showed a majority of the coefficients less than .1. These results are disappointing from the aspect of elasticity size. They do indicate that as hypothesized, weather was a strong factor and its influence grew as income increased.

The total percent of the customers who exhibited a significant weather variable at the ten percent level or better was: I, 58.8; II, 59.5; III, 76.4; IV, 73.7; V, 71.8; VI, 69.3; VII, 80.8; and VIII, 67.8. This finding showed a striking similarity to the results of the general population. One minor difference was noted by analysis of the weather results. Apparently, homes occupied by the widow and/or retired groups tended to have air conditioning at slightly lower incomes than the general population, in the \$5,000 plus income range rather than the \$7,500 plus range. Overall, a slightly smaller percent in this group exhibited significance for the weather variable. However, the results of this variable indicate that a further modification is needed to fully extract the impact of weather on electricity use.

Since income was not a variable in the regressions, the \bar{R}^2 's were expected to be low. The unweighted averages of the \bar{R}^2 's were from .30 for income class VIII to .49 for income class II. A pattern of decreasing explanatory power was noted from income group II through income

Table 6. Trend variable results for the combined sample (all values in percentage).

Income Class	Positive and Significant at 5 Percent Level	Added Positive and Significant at 10 Percent Level	Total Positive and Significant at 10 Percent Level or Better	Positive but not Significant	Negative	Total Positive
I	70.6	0.0	70.6	11.8	17.6	82.4
II	65.9	4.5	70.4	11.4	18.2	81.8
III	56.9	6.9	63.8	16.7	19.5	80.5
IV	46.7	9.5	56.2	27.0	16.8	83.2
V	33.8	14.8	48.6	28.2	23.2	76.8
VI	32.3	9.2	41.5	35.4	23.1	76.9
VII	42.3	15.4	57.7	26.9	15.4	84.6
VIII	38.7	12.9	51.6	35.5	12.9	87.1
Totals	44.6	10.3	54.9	25.7	19.4	80.5

Demand for Electricity

group VI before rising for income group VII. This result is similar to the general population although the decline is less for this group.

Weighted Price Elasticity

An attempt was made to extend the results of the sample to the population of Alabama for widows and/or retired persons. To apply the price elasticities for Alabama, the unweighted elasticities were first weighted by average use in each income class. Then an estimate of the percentage of total customers in each income class for the State was made. The weighted price elasticities were then weighted again to give an average elasticity for the entire State. These computations for the combined sample yielded a double-weighted coefficient of $-.791$.

A word of caution is necessary at this point. The percentages applied to the fraction of Alabama population in each income class are not strictly applicable to the widow and/or retired population. Also, to the extent that a difference exists between urban and rural customers, an urban bias would be included in the estimate. However, no other figures are available and these should provide at least a rough approximation for response estimation.

The double-weighted price elasticity coefficient of $-.791$ is considerably higher in absolute terms than the coefficient for the general population ($-.45$). This result was anticipated as older persons and persons on fixed incomes would be expected to respond more strongly to price increases. Simply interpreted, the coefficient means that for every one percent increase in the price of residential electricity, widows and/or retired persons in Alabama tended to reduce consumption by $.791$ percent on the average.

In conclusion, this study provided evidence that the widows and/or retired customers of electricity in Alabama responded in a similar manner to several variables in much the same manner as the general population. [3] In terms of levels of consumption, electricity usage increased as income increased for the widows and/or retired customers. As anticipated these groups consumed less electricity than the general population, even within the same income levels. Evidence was provided that the widows and/or retired customers responded to price change more strongly than the general population, i.e., they exhibited a higher price elasticity. This result may well reflect two things: a stronger willingness and/or ability to reduce consumption by the higher income groups and a stronger need to reduce consumption by the lower income groups. Over fifty-five percent of the widow and/or retired customers in the sample showed a significant response to the appeal for conservation. This result was only slightly higher than the results for the general population.

REFERENCES

- (1) Berman, M. B., and Morlie Hammer Graubard. "A Model of Residential Electricity Consumption." The Rand Corporation, Santa Monica, California: July 1973.

- (2) Lacy, A. Wayne, and Donald R. Street. "A Single Firm Analysis of the Residential Demand for Electricity," *Proceedings of South-eastern American Institute for Decisions Sciences*, February, 1977.
- (3) Lacy, A. Wayne, and Donald R. Street, "Electricity Use in Alabama by Income Class with Implications Regarding the Effectiveness of Lifeline Rate Structures," *Journal of the Alabama Academy of Science*, Vol. 48, No. 4, October, 1977.
- (4) Lacy, A. Wayne, and Donald R. Street. "The Residential Demand for Electricity by Income Class," *Midsouth Journal of Economics*, Vol. 3, No. 1, 1979.
- (5) Lacy, A. Wayne, Donald R. Street, and Walter L. Baker. "Income Determines Level of KWHour Use," *Electrical World*, Vol. 186 (July, 1976).
- (6) Street, Donald R., A. Wayne Lacy, and Carl W. Hale. *An Analysis of Plans to Aid Low-Income Electricity Users*. Birmingham: November, 1975.
- (7) Taylor, Lester D. "The Demand for Electricity: A Survey," *The Bell Journal of Economics*, Vol. 6, No. 1 (Spring, 1975).

POWER PLANT RECIRCULATION AND ENTRAINMENT IMPACT:
A SOLUTION FOR CONSTANT RECIRCULATION
AND ONCE-THROUGH MORTALITY RATES^{1,2}

William E. Cooper, Jr.³
Hudson River Ecological Survey
Texas Instruments, Inc.
P.O. Box 237
Buchanan, NY 10511

One of the several environmental impacts of electrical generating plants is the transport of passive planktonic organisms through the plants in cooling water. Entrainment, as this phenomenon has come to be known, induces an increase in mortality of various phytoplankters and zooplankters by subjecting them to thermal (Schubel, 1975) and mechanical (Ulanowicz, 1975; Marcy, 1975; Flemer, 1971; Lauer, 1974) stress. Power plant-induced mortality to game fish and commercial food fish is of particular concern, especially mortality of eggs and ichthyoplanktonic (larval) stages. In species of fish having pelagic, nonadhesive eggs with a specific gravity near that of water, susceptibility to entrainment is maximized because the eggs tend to float in the water column (Lagler et al., 1977). The demersal eggs of many other species remain at the bottom and are thus less subject to entrainment. Some larvae are available for entrainment even after they become nektonic.

Since early studies suggested a very high percentage mortality of ichthyoplankton due to entrainment, it has often been assumed that all entrained eggs and ichthyoplankton are killed. However, some survival was reported in five of nine studies reviewed by Marcy (1975). Furthermore, many existing power plants could reduce mortality by increasing recirculation of cooling water.

The conservative position that there is neither recirculation through a power plant nor survival of entrained ichthyoplankton provides maximal entrainment impact estimates. More realistic estimates may be obtained by considering effects of various recirculation and survival regimes, but without detailed knowledge of the functional relationships between hydrological parameters, flow patterns, and ichthyoplankton mortality existing at a given power plant, it is difficult to determine the

¹Manuscript received 11 September 1979; accepted 8 February 1980.

²This work was partially supported by Consolidated Edison, Texas Instruments, Inc., and Auburn University at Montgomery.

³Current Address: Department of Biology, Auburn University at Montgomery, Montgomery, AL 36117.

exact degree to which impact may be reduced by recirculation of water through the plant and by survival of entrained organisms. Detailed studies of the above variables can be made for particular power plants when the expense is justified by legal requirements and/or suspected entrainment problems.

By making certain simplifying assumptions, it is possible in the absence of such studies to obtain an approximation of the effects of recirculation and survival on entrainment impact. First, it is assumed that of the total volume of water in a power plant at a given time, a constant proportion, R , has been recirculated. Thus $(1-R)$ of the total water is in the plant for the first time, $(1-R)R$ for the second, $(1-R)R^2$ for the third, and so on. Next, it is assumed that a constant proportion, M , of a given ichthyoplanktonic life stage present in a volume of water is killed each time that volume passes through the power plant. This assumption would overestimate the reduction of impact due to survival if once-through survival is greater than survival upon recirculation. Since the trauma of first passage through the plant very probably reduces the viability of those organisms which do survive, the assumption of a constant proportional mortality may provide the lower limiting estimate of impact for a given level of once-through mortality. It is conceivable, but extremely improbable, that once-through mortality could be greater than that experienced during subsequent passages through a power plant. If such were the case, the assumption of constant mortality would result in overestimation of entrainment impact.

To develop an expression accounting for both survival and recirculation, consider the entrained water in a power plant at a given time. Under the assumptions that (1) the proportion of water which has been recirculated is constant and (2) proportional mortality is constant for all passages through the plant, the total number of ichthyoplankton killed in a given time interval may be determined by summing the numbers killed in first, second and subsequent passages through the plant. On first passage, the number killed is given by the product of the number entrained, the once-through mortality, and the proportion of the total water volume which is first-passage water, i.e.,

$$N_{k1} = NeM(1-R),$$

where, R and M are the recirculation and mortality factors defined above, Ne is the number of organisms entrained during the interval and N_{k1} is the number killed on 1st passage. On later passages both volume and density are reduced so that

$$N_{k2} = NeM(1-R)R(1-M),$$

$$N_{k3} = NeM(1-R)R^2(1-M)^2,$$

$$N_{kn} = NeM(1-R)R^n(1-M)^n,$$

(This derivation assumes that organisms recirculate exactly as does the water, without augmentation or diminution of density due to movements of the organisms into or out of the recirculating water mass.)

Power Plant Recirculation

Summing all the terms above, we have $N_{k.} = NeM(1-R) \sum_{n=0}^{\infty} [R(1-M)]^n$,

where $N_{k.}$ is the total number of animals killed by entrainment during the interval. The sum of the infinite geometric series exists since $R(1-M)$ is always between zero and one unless there is complete recirculation and no mortality. The sum is:

$$\sum_{n=0}^{\infty} [R(1-M)]^n = \frac{1}{1 - R + RM} .$$

Therefore,

$$N_{k.} = Ne \frac{M(1-R)}{1 - R + RM} = Ne \left(\frac{M - RM}{1 - R + RM} \right) .$$

It is desirable in studies of power plant impact to obtain estimates of proportional reduction of a population due to entrainment. If ichthyoplankton density is the same in entrained water and the surrounding water mass, then the proportion killed may be estimated from the fraction of total water in the vicinity which is entrained (the withdrawal ratio), with appropriate reduction for recirculation and survival. The proportional entrainment impact thus equals the entrainment with no recirculation and no survival multiplied by a fractional term accounting for the effects of existing survival and recirculation.

The reduction of entrainment impact due to recirculation and survival is $1 - \frac{(M - RM)}{(1 - R + RM)}$. In Fig. 1, this proportional reduction of impact is plotted on the ordinate against percentage recirculation on the abscissa. A family of curves is thus generated, one corresponding to each level of once-through mortality. As shown in Fig. 1, impact is eliminated when there is no mortality or complete recirculation. This can be anticipated from the corresponding sums of the geometric progression. With $M = 0$ or $R = 1$,

$$\frac{M(1-R)}{1 - R + RM} = 0 .$$

When mortality is total, impact is reduced by exactly the degree to which water is recirculated; when no recirculation occurs, the reduction of impact is simply the percentage of organisms surviving one passage through a plant, i.e., when $M = 1$,

$$1 - \left[\frac{M(1-R)}{1 - R + RM} \right] (100) = (1-R)(100) .$$

When there is no recirculation ($R = 0$), the mortality should be equal to the once-through mortality, M . We have $\frac{M(1-R)}{1 - R + RM} = M$, as required.

Between the extremes of complete survival and complete mortality, reduction of impact is not linearly related to recirculation.

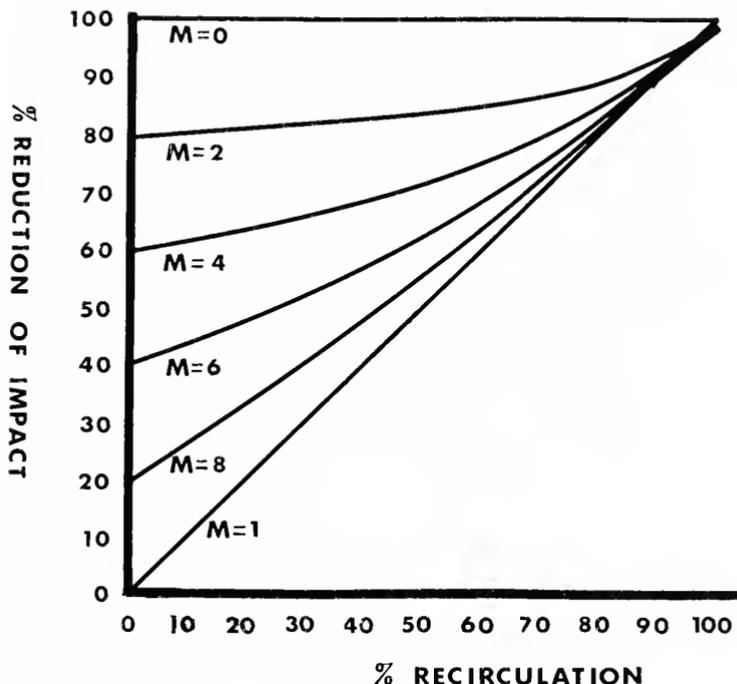


Fig. 1. The proportional decrease of entrainment impact calculated by accounting for recirculation of cooling water and survival of entrained ichthyoplankton is shown. Percentage reduction of impact is read on the ordinate for a particular abscissal value of percent recirculation at the appropriate once-through mortality, shown as separate curves for selected mortality levels.

LITERATURE CITED

- Flemer, D. A. 1971. The effects of steam electric station operation on entrained organisms. In J. A. Mihursky and A. J. McErlean, Post-operative assessment of the effects of estaurine power plants. Nat. Res. Institut., Ref. No. 17-26.
- Lagler, K. F., J. E. Bardach, and R. E. Miller. 1977. *Ichthyology*, 2nd ed., John Wiley and Sons, New York, 1-506.
- Lauer, G. J., W. J. Waller, and D. W. Bath. 1974. Fish egg and larvae entrainment by the Indian Point Power Plant on the Hudson River estuary. Paper presented at the N.E. Div. Amer. Fish. Soc. Meeting (February, 1974).
- Marcy, B. C. 1975. Entrainment of organisms at power plants, with emphasis on fishes--an overview. In S. B. Saila, ed., Fisheries and Energy Production: A Symposium, D. C. Heath, Lexington, Mass., 89-106.

INTERACTION OF NOISE STRESS WITH ADRENOCORTICAL
RESPONSIVENESS TO *IN VIVO* AND *IN VITRO*
ACTH STIMULATION¹

W. F. Johnson, J. F. Pritchett, M. L. Till, and W. L. Harper

*Department of Zoology-Entomology
School of Agriculture and Agricultural Experimental Station
Auburn University
Auburn, AL 36830*

*D. N. Marple
Department of Animal and Dairy Science
School of Agriculture and Agricultural Experimental Station
Auburn University
Auburn, AL 36830*

Abstract. The present study was undertaken to clarify further the interaction of intermittent high-intensity noise with the hypothalamic-pituitary-adrenal cortical axis. Male rats (Sprague-Dawley) were subjected to high intensity white noise (110 dBA sound pressure level) for 60 seconds followed by 300 seconds of silence, continuously for 28 consecutive days.

Although injected ACTH (1 or 3 IU) elevated plasma levels of corticosterone significantly in both the noise-stressed and control animals, no noise-ACTH interaction with this variable was detected. While both levels of injected ACTH elevated *in vitro* corticosterone secretion in control animals, noise-stressed animals responded only to the higher ACTH dose level. Response to *in vitro* ACTH stimulation during initial incubation was significantly lower in the noise-stressed animals. During an ensuing incubation, all adrenals responded identically to any given ACTH level, regardless of noise stress status.

The data suggest the presence of a noise-related factor (or factors) of unknown origin which may antagonize the expression of ACTH on the adrenal cortex both *in vivo* and *in vitro*. The *in vitro* action of the factor is in turn diminished or removed when glands are reincubated in fresh medium.

INTRODUCTION

Previous reports on the effects of noise upon the adrenal cortex have indicated varied response patterns, due largely to the different types of noise utilized as well as the duration and intensity of the

¹Manuscript received 14 August 1979; accepted 19 September 1979.

noise. However, most of these reports have been based upon indirect indices of adrenal cortical activity.

Anthony and Ackerman (1955) reported a decrease in circulating eosinophils (indicative of increased cortical activity) in mice exposed to 110 dBA of white noise in the 10-20 kHz band at a 100 minutes on/100 minutes off pattern for several time periods. Geber et al. (1966) also noted a decline in this same variable in rats subjected to noise from a combination of sources. Adrenal ascorbic acid, the concentration of which is inversely related to cortical activity, has been reported to increase (Anthony et al., 1959), decrease (Gerber et al., 1966), or remain unchanged (Sackler et al., 1960), depending upon intensity and duration of noise exposure. Hrubes and Benes (1965) have reported an increase in adrenal weight in noise-exposed (95 dBA) rats while Osintseva et al. (1959) have reported a decrease in adrenal weight in rats exposed to a similar noise intensity for different periods of time. Sackler et al. (1960) observed no change in adrenal weight in rats exposed to different types of noise sources generating intensities ranging from 90-120 dBA.

More recently, in our laboratories, Pritchett et al. (1976) have applied *in vitro* methodology described by Bakker and deWied (1961) to noise-stressed mice collected from fields in close proximity to the runways of a modern jetport. Utilizing more direct indices of cortical function, they reported a depression of adrenocortical responsiveness to *in vitro* ACTH stimulation as opposed to that demonstrated by the adrenals of mice collected in a similar field several kilometers from the airport. The effect was further investigated in wild cotton rats (Pritchett et al., 1978) stressed with recorded jet aircraft noise under laboratory conditions. This same lack of responsiveness of adrenocortical secretion rates of noise-stressed animals to *in vitro* ACTH stimulation was found. Also reported was a depression in cyclic-AMP accumulation in the noise-stressed adrenals in response to *in vitro* ACTH.

The present study was undertaken to determine if these responses would occur in laboratory animals under standardized laboratory conditions which eliminate variables such as seasonal variations, age of the animals, parasite burdens and/or disease conditions present in wild species. Also considered in this study was whether the lack of *in vitro* adrenal cortical responsiveness to ACTH was related to the mode of introduction of this trophic factor to the gland, i.e., *in vitro* versus *in vivo*.

MATERIALS AND METHODS

Male Sprague-Dawley derived rats (Southern Animal Farm), 70-90 days of age, were utilized in this two-phase study. The animals were housed three per cage at $24 \pm .5^{\circ}\text{C}$ with a photoperiod of 14 hours light/10 hours darkness. Animals were provided Purina Laboratory Chow and tap water *ad libitum*.

Animals to be exposed to the noise regimen were subsequently removed to an isolation room and maintained under the same environmental

conditions as previously described. Noise exposure consisted of a pattern of 60 seconds of recorded white noise¹ (110 dBA sound pressure level, SPL) followed by 300 seconds of ambient sound continuously for 28 consecutive days. Ambient SPL in both the control and noise treatment areas was 25 ± 5 dBA.

At the end of the treatment period, both control and noise exposed animals were killed by decapitation between 1900-2100 hours. Trunk blood was collected for plasma corticosterone analysis. The adrenals were quickly removed, trimmed of extraneous tissue on chilled filter paper moistened with Krebs-Ringer Bicarbonate-Glucose (KRBG), blotted, and weighed on an analytical balance to the nearest 0.1 mg. Individual glands were quartered and then placed in a flask containing 2 ml of KRBG either with or without added ACTH, and initially incubated for 60 minutes in a Dubnoff Metabolic Shaker (60 oscillations per minute, 37°C, 95% O₂/5% CO₂ atmosphere). Following the initial incubation, the glands were transferred to a second flask containing 2 ml fresh KRBG with added ACTH and subjected to a second 60 minute incubation. All incubation media were transferred to marked vials and frozen (-20°C) prior to corticosterone analysis.

In vivo ACTH Stimulation and Responsiveness

One hour prior to sacrifice, control and noise-exposed animals were randomly assigned to 1 of 4 treatments: uninjected, saline injected (0.5 ml 0.9% NaCl), and ACTH injected (1 unit or 3 units of ACTH, Nutritional Biochemicals Corporation, Cleveland, in 0.5 ml saline). All injections were subcutaneous. One hour post injection, animals were sacrificed and trunk blood was collected in heparinized tubes. Adrenal quarters were incubated in KRBG (no ACTH) for an initial 60 minutes followed by a second incubation in KRBG containing 200 mU/ml ACTH (Sigma Biochemicals).

In vitro Stimulation and Responsiveness

Control and noise-exposed animals were sacrificed and the adrenals were incubated either in the absence of ACTH or in medium fortified with 50, 200, or 400 mU/ml ACTH. The glands were then transferred to a second incubation and exposed to either 50, 200, or 400 mU/ml ACTH.

Corticosterone Analysis

Assay of incubation medium and plasma samples for corticosterone was accomplished by a modification of the competitive protein-binding radioassay (CPB) described by Murphy (1967, 1971), utilizing rabbit serum as the source of the binding ligand and 1, 2-³H (N) corticosterone (New England Nuclear) as the radiolabel. Incubation media were diluted and assayed directly. Plasma samples were first extracted with dichloromethane and then assayed.

¹White noise is defined as random wave form patterns carrying equal energy per bandwidth over the entire audible range (20Hz-20kHz).

Statistical Analyses

The data were subjected to a least squares analysis of variance. The main effects of noise, *in vitro* ACTH and injected ACTH (where applicable) were determined. In cases of significant interaction, differences between appropriate means were analyzed utilizing Student's "t" test.

RESULTS

Weight Relationships

Body weight, adrenal weight, and adrenal:body weight ratio data were pooled across the two phases of the experiment since *in vitro* treatments were applied after weight determinations were made and since *in vivo* ACTH injections would not be expected to affect body and/or adrenal weight within one hour. Results are summarized in Table 1.

Table 1. Effects of noise stress on body and adrenal weight relationships.^a

Treatment	N	Body Weight (grams)	Adrenal Weight (mg wet weight)	Adrenal:Body Weight Ratio (mg/100 g)
Control	60	528 ± 6	50.50 ± 0.86	9.60 ± 0.18
Noise	60	508 ± 6 ^b	49.08 ± 0.86	9.69 ± 0.18

^aAll values are means ± SEM, SEM derived from analysis of variance error mean square value.

^bSignificantly different from control ($p < .02$).

Noise-stressed animals exhibited significantly lower body weights than did the control animals. However, neither adrenal weights nor adrenal:body weight ratios were different in comparison of the noise and control groups.

Response to in vitro ACTH Stimulation

Comparisons of *in vitro* adrenal secretory responses to *in vitro* ACTH of control and noise-stressed animals are presented in Table 2. Adrenal glands from the control animals responded with a significant ($p < .025$) increase in secretion rate over the basal rate when stimulated with any of the three dose levels of ACTH during the first incubation. However, in the noise-stressed animals, adrenals responded with elevated secretory activity ($p < .025$) only when exposed to the 200 and 400 mU/ml dose levels.

Noise Stress and ACTH Stimulation

Table 2. Effects of noise stress and *in vitro* ACTH stimulation on adrenal secretion rates of corticosterone during an initial 60 minute incubation.^a

ACTH dose (mU/ml)	N	Control (nanograms/mg tissue)	Noise (nanograms/mg tissue)
Basal	18	67.35 ± 5.61	61.29 ± 5.61
50	6	83.17 ± 9.71 ^b	64.44 ± 9.71
200	6	95.33 ± 9.71 ^b	87.57 ± 9.71 ^b
400	6	84.31 ± 9.71 ^b	112.17 ± 9.71 ^b

^aAll values represent means ± SEM. SEM derived from analysis of variance error mean square.

^bWithin columns, values so indicated are significantly greater than basal values ($p < .025$).

Table 3 summarizes *in vitro* adrenocortical activity in the control and noise-stressed groups during a second incubation containing one of three ACTH dose levels either after an initial incubation with no ACTH or after an initial incubation containing the same level of ACTH. Statistical analysis of this set of data indicates no significant difference in ACTH responsiveness between noise and control groups receiving ACTH treatment in the second incubation regardless of the level of ACTH treatment in the initial incubation.

Table 3. Effects of noise stress and preincubation ACTH treatment on ACTH-induced adrenal secretion rates of corticosterone during a second 60 minute incubation.^a

ACTH Dose	Control		Noise	
	Basal Preincubation ^b (nanograms/mg tissue)	ACTH Preincubation ^c (nanograms/mg tissue)	Basal Preincubation ^b (nanograms/mg tissue)	ACTH Preincubation ^c (nanograms/mg tissue)
50	70.88 ± 15.86	82.33 ± 11.85	83.45 ± 15.86	87.73 ± 11.85
200	104.30 ± 15.86	111.61 ± 7.87	100.21 ± 15.86	119.72 ± 7.87
400	139.98 ± 15.86 ^d	108.73 ± 11.85	120.95 ± 15.86 ^d	130.54 ± 11.85 ^d

^aAll values represent the means ± SEM of 6 observations. SEM was derived from analysis of variance error mean square.

^bA first incubation contained no ACTH.

Table 3. Continued

^cFirst incubation contained same ACTH dose as second incubation.

^dWithin columns, values so indicated are significantly greater than 50 mU ACTH values ($p < .05$).

In vitro Response to Injected ACTH

Changes in *in vitro* adrenal activity in response to noise exposure and *in vivo* administration of ACTH are presented in Table 4. These data are the result of an initial incubation containing no ACTH, and represent an estimate of *in vivo* adrenocortical activity at the time of sacrifice.

Table 4. Effects of noise stress and *in vivo* ACTH injection upon *in vitro* adrenal secretion rate of corticosterone during an initial 60 minute incubation.^a

Injection Treatment	N	Control (nanograms/mg gland)	Noise (nanograms/mg gland)
No Injection	6	66.92 ^b	43.94 ^b
Saline	6	55.65	64.05
ACTH (1 Unit)	6	93.44 ^c	77.92
ACTH (3 Units)	6	93.79 ^c	91.74 ^c

^aAll values represent means. SEM for all values = 6.61 and was derived from analysis of variance error mean square.

^bValues so indicated differ significantly ($p < .05$).

^cWithin columns, values so indicated differ significantly from saline values ($p < .01$).

Non-injected, noise-stressed animals exhibited a significantly ($p < .05$) lower secretory rate than did their control counterparts. Considering ACTH responsiveness, 1 unit of the trophic factor produced a highly significant ($p < .01$) increase in adrenal activity in the control group over the control saline-injected group. However, this same treatment failed to elicit a significant increase from the adrenals of the noise-stressed animals. Injection with 3 IU ACTH produced a significant ($p < .01$) increase in secretion over the saline-injected animals in both the control and noise exposed groups.

In vivo Response to Injected ACTH

Table 5 summarizes the effect of noise stress and injected ACTH upon plasma corticosterone levels. The concentrations of circulating

Noise Stress and ACTH Stimulation

corticoids were lower ($p < .10$) in the noise-stressed non-injected animals as compared to their control counterparts. Subcutaneous injection of either 1 unit or 3 units of ACTH was sufficient to elicit a significant increase in plasma corticoids (compared to the saline-injected animals) in both the control and noise-stressed animals. In both cases, animals injected with 3 units of ACTH responded with higher corticoid levels in the blood than animals in the same group injected with 1 unit of ACTH. However, although both groups responded to different doses with a similar magnitude of increase, the plasma corticoid levels observed in the noise-stressed animals were consistently below the levels measured in the control group.

Table 5. Noise stress and *in vivo* ACTH injection effects on plasma corticosterone levels.^a

Injection Treatment	N	Control (nanograms/ml)	Noise (nanograms/ml)
No Injection	6	215.64	161.40 ^b
Saline	6	221.12	196.97
ACTH (1 Unit)	6	329.15 ^c	309.27 ^c
ACTH (3 Units)	6	373.66 ^c	321.51 ^{b,c}

^aAll values represent means. SEM for all values = 36.47 and was derived from analysis of variance error mean square value.

^bWithin rows, values so indicated differ from control ($p < .10$).

^cWithin columns, values so indicated differ from saline values ($p < .025$).

DISCUSSION

The existence of an inhibitory substance or condition which diminishes the expression of ACTH on the adrenal cortex, and which is present only (or present in higher quantities) in the adrenals of noise-stressed rats is strongly suggested by our data. The characteristics of this antagonism seem to follow those first described by Bakker and deWied (1961), and later by Pritchett et al. (1978) in wild rats. These prior reports noted a noise-related lack of ACTH responsiveness in an initial incubation followed by a return of ACTH responsiveness in subsequent incubations. It has been postulated, based on the findings of these experiments, that antagonistic factor(s) accumulated in the medium of the first incubation. Thus, in succeeding incubations in fresh media, the antagonistic factor(s) are either present in diminished quantities or absent. Consequently, adrenal tissue may respond to a greater extent to ACTH after an initial incubation.

Classically adrenals have been preincubated for 30 minutes or more so as to increase uniformity of adrenal cortical responsiveness to ACTH in ensuing incubations and to remove the influence of endogenous ACTH (Saffran et al., 1952; Saffran and Bayliss, 1953; Bakker and deWied, 1961). Consequently, initial incubation media have been discarded without analysis in studies dealing with ACTH responsiveness. However, since it has been reported that basal *in vitro* production of adrenal steroids is a reliable index of *in vivo* cortical activity at the moment of the animal's death (deWied et al., 1964), both basal and ACTH-stimulated initial incubation secretory rates of corticosterone have been analyzed in the present study.

Comparison of the secretion rates in first incubations in both the *in vitro* and *in vivo* (injected) ACTH experiments (Tables 2 and 4) illustrate a significant increase in cortical secretion in response to every dose level of ACTH by the control animals. However, noise-stressed animals responded only to the higher levels of ACTH stimulation during initial incubation. Second incubation results (Table 3) indicate no differences in corticosterone secretion due to either noise stress or ACTH pretreatment at any second-incubation ACTH dose level.

Basal adrenal secretion rates (Table 4) were significantly lower in the noise-stressed animals than in the control animals. This does not agree with results obtained by other authors who used the same techniques of *in vitro* determination of adrenocortical activity after stress: Bakker and deWied (1961), who subjected their animals to a different type of stressor for a short period of time; and Pritchett and coworkers (1978) who studied wild animals.

Plasma corticoid levels (Table 5) also show a trend toward a decrease in basal values in noise-exposed as compared to control animals. Although this difference is non-significant, it should be noted that the plasma levels in noise-stressed rats were consistently lower than in the controls for each injection treatment. Furthermore, the response to the high dosage of ACTH (3 units injected) in the noise-stressed animals was not different from the response of the controls to the 1 unit dose of injected ACTH. It would therefore appear that a degree of ACTH antagonism is present not only *in vitro* but also *in vivo*.

Endogenous ACTH levels were not monitored. However, if continuous, high-volume noise exposure is to be considered a biological stressor, it may be assumed that plasma ACTH levels were elevated. Since increased adrenal output is the animal's natural response to stress and since the animal's control of the adrenal cortex is through ACTH release, it is suggested that the decreased plasma levels of corticosterone in the noise-stressed animals may be a result of ACTH antagonism within the animal.

Lower levels of ACTH stimulation, both *in vitro* and *in vivo* (Tables 2 and 4), failed to elicit a significant increase in corticosterone production over the appropriate control in the noise-stressed animals. However, these same treatments were sufficient to produce significant increases in the control animals. These data suggest that the inhibitory

system may actively compete with an endogenous compound somewhere within the adrenocortical activating system. Pritchett et al. (1978) have demonstrated that adrenal cyclic AMP accumulation follows the same pattern of inhibition of response to ACTH stimulation after noise stress as does corticosterone formation. They have proposed that inhibition occurs prior to the formation of cyclic-AMP in the adrenal cortex. Birmingham and Kurlents (1958) and Bakker and deWied (1961) induced *in vitro* inhibition of cortical response to ACTH by incubating adrenals in medium in which other adrenals had been incubated. Furthermore, the latter investigators have reported that when this preincubation medium is heated prior to reuse as an incubation medium, ACTH antagonism is absent. This suggests that the antagonistic substance may be protein-like in nature. Assuming a protein nature for the antagonist, it is possible that inhibition may be accomplished (A) at the receptor level by direct competition with ACTH, (B) through altered ACTH metabolism prior to ACTH combination with the receptor, or (C) via altered activity of the ACTH-receptor complex.

Evidence for the existence of an ACTH antagonist raises several questions concerning its origin and purpose. Why is the antagonist present? Why would its activity be increased during periods of stress when adrenal corticosteroids are required in optimal quantities? Can the antagonist have survival value to the animal? It may be postulated that after chronic stress (i.e., lasting for an extended period of time) the organism may diminish its response to ACTH so as to maintain a functional reserve for further or additional stressors. Perhaps this modulation mechanism is not via a change in the pituitary feedback loop nor through attenuation of ACTH release but rather is the result of inhibition of ACTH expression on the receptors of the adrenal cortex. Even though this regulation would permit only small increases in adrenal output in response to additional stress, it would be effective in preventing adrenal exhaustion which in turn could result in the death of the animal.

LITERATURE CITED

- Anthony, A., and E. Ackerman. 1955. Effects of noise on the blood eosinophil levels and adrenals of mice. *J. Acoustical Soc. Amer.* 27(6):1144-1149.
- Anthony, A, E. Ackerman, and J. A. Lloyd. 1959. Noise stress in laboratory rodents. I. Behavioural and endocrine response of mice, rats, and guinea pigs. *J. Acoustical Soc. Amer.* 31:1430-1440.
- Bakker, R. F. M., and D. deWied. 1961. The effect of corticotropin on the formation of corticosteroids *in vitro*. *Can. J. Biochem. Physiology* 39:23-29.
- Birmingham, M. K., and E. Kurlents. 1958. Inactivation of ACTH by isolated rat adrenals and inhibition of corticoid formation by adrenocortical hormones. *Endo.* 62:47-60.
- deWied, D., B. Van Der Wal, and J. J. Van Goch. 1964. Glucocorticoid and mineralocorticoid production *in vitro* as an index of *in vivo* adrenocortical activity. *Excerpta Medica Int. Congr. Ser.* 83(1): 64-69.

- Geber, W. F., T. A. Anderson, and B. van Dyne. 1966. Physiologic responses of the albino rat to chronic stress. *Arch. Envir. Health* 12:751-754.
- Hrubes, V., and V. Benes. 1965. Uber den Einfluss weiderholter Larmbelastung auf Ratten. (The influence of repeated noise stress on rats.) *Acta Biol. Med. Germanica* 15:592-596.
- Murphy, B. E. P. 1967. Some studies of the protein-binding of steroids and their application to the routine micro and ultramicro measurement of various steroids in body fluids by competitive protein-binding radioassay. *J. Clin. Endo. Metal.* 27:973.
- Murphy, B. E. P. 1971. Hormone assay using binding proteins in blood. Pages 108-127 in W. D. Odell and W. H. Daughaday, eds. *Principles of competitive protein-binding assays*. Lippincott, Philadelphia.
- Osintseva, V. P., N. N. Pushkina, T. I. Bonashevskaya, and V. F. Kaverina. 1969. Noise-induced changes in the adrenals. *Hygiene and Sanitation* 34:147-151.
- Pritchett, J. F., M. L. Browder, R. S. Caldwell, and J. L. Sartin. 1978. Noise stress and *in vitro* adrenocortical responsiveness in wild cotton rats, *Sigmodon hispidus*. *Envir. Res.* 16:29-37.
- Pritchett, J. F., R. S. Caldwell, R. K. Chesser, and J. L. Sartin. 1976. Effect of jet aircraft noise upon *in vitro* adrenocortical response to ACTH in feral *Mus musculus*. *Life Sci.* 18:391-396.
- Sackler, A. M., A. S. Weltman, and P. Jurtshuk. 1960. Endocrine aspects of auditory stress. *Aerospace Med.* 31:749-759.
- Saffran, M., B. Grad, and M. J. Bayliss. 1952. Production of corticoids by rat adrenals *in vitro*. *Endo.* 50:639-643.
- Saffran, M., and M. J. Bayliss. 1953. *In vitro* bioassay of corticotrophin. *Endo.* 52:140.

FUNGI OF ALABAMA. IX. DEMATIACEOUS HYPHOMYCETES¹

G. Morgan-Jones

Department of Botany, Plant Pathology, and Microbiology
Auburn University Agricultural Experiment Station
Auburn, AL 36830

INTRODUCTION

Ten dematiaceous hyphomycetes collected in Alabama are described and illustrated.

TAXONOMIC PART

Anungitea fragilis Sutton, Mycol. Pap. 132: 10, 1973 (Fig. 1).

Colonies effuse, brown, hairy. Mycelium immersed in the substratum, or partly superficial, composed of branched, septate, pale brown to brown, smooth, 2.5-4 μ m wide hyphae. Conidiophores macronematous, mononematous, simple, erect, straight or slightly flexuous, smooth, septate, cylindrical, swollen at the base, brown, becoming progressively paler and attenuating towards the apex, 48-65 \times 3-4 μ m. Conidiogenous cells polyblastic, terminal, integrated, sympodial, pale brown to subhyaline, smooth, cicatrized, scars conspicuous, somewhat swollen in the scar bearing region. Conidia holoblastic, solitary or more frequently catenate, dry, acropleurogenous, simple, formed in unbranched acropetal chains, subhyaline, cylindrical, 1-septate, smooth, bearing a narrow truncate scar at one or both ends, 10-12 \times 1.5 μ m.

On dead petiole of *Quercus* sp., Auburn University Forestry Plots, Auburn, Lee County, Alabama, May 18, 1978, R. C. Sinclair, AUA.

The monotypic genus *Anungitea* Sutton, type species *A. fragilis* Sutton, was described from a single collection made on dead bark of *Abies balsamea* (L.) Mill. at Whiteshell Provincial Park, Manitoba, Canada, in 1969. The Alabama collection is the first record of its occurrence in the United States and, to my knowledge, the second ever made.

Bispora betulina (Corda) Hughes, Can. J. Bot. 36: 740, 1958 (Fig. 2).

\equiv *Dicoccum betulinum* Corda, Icon. Fung. 2: 5, 1838.

For full nomenclator see Hughes (1958).

Colonies punctiform to effuse, dark brown. Mycelium mostly immersed in the substratum, sometimes partly superficial, composed of branched, septate, smooth, pale brown to brown, 2-3.5 μ m wide hyphae. Conidiophores semimacronematous, mononematous, short, inconspicuous,

¹Manuscript received 23 August 1979; accepted 12 October 1979.

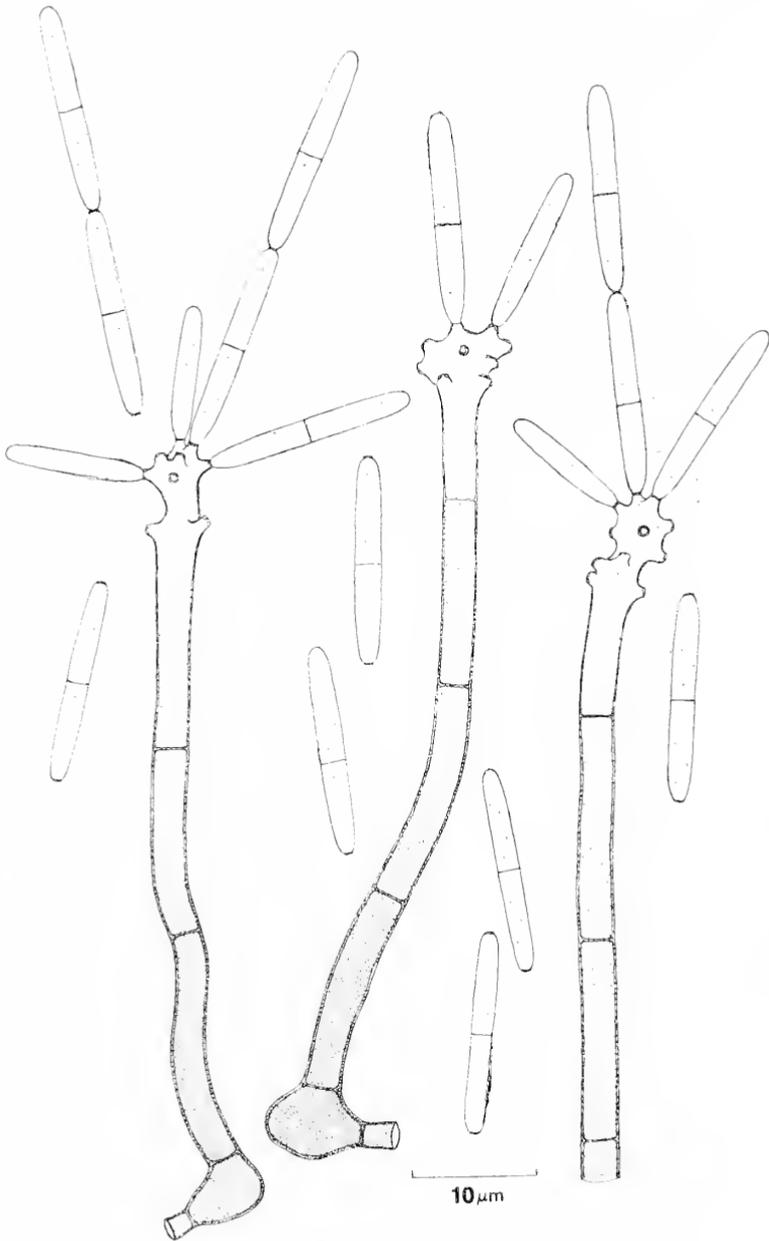


Figure 1. *Amungitea fragilis*

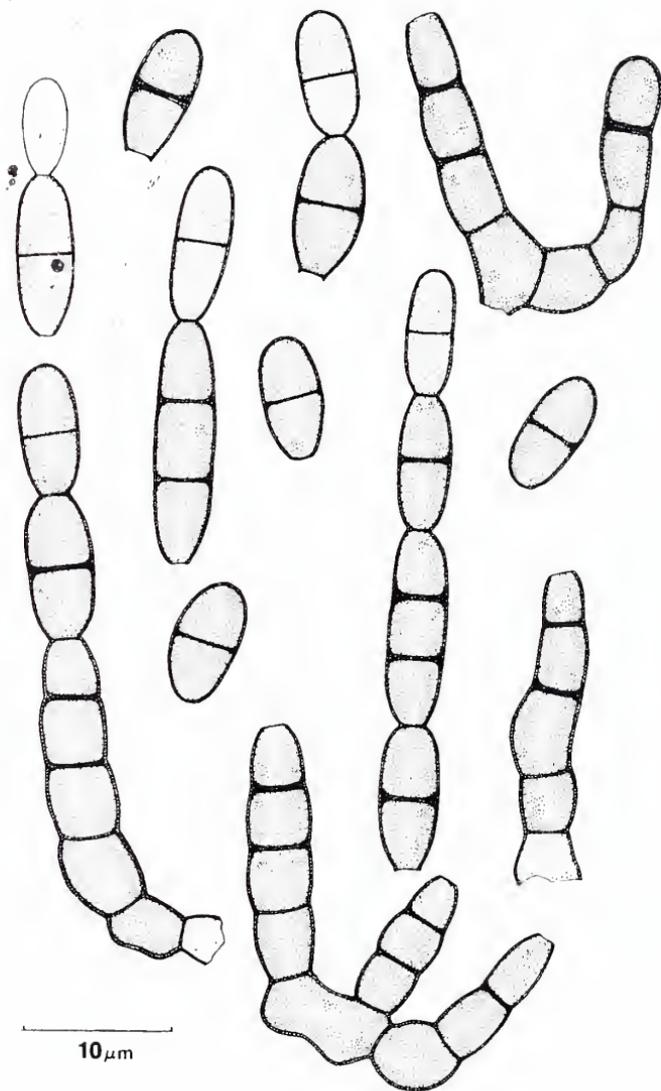


Figure 2. *Bispora betulina*

more or less cylindrical, septate, usually slightly constricted at the septa, pale brown to brown, $6-20 \times 3-4\mu\text{m}$. Conidiogenous cells monoblastic, integrated, terminal, determinate. Conidia holoblastic, catenate, acrogenous, simple, elliptical to somewhat barrel-shaped, rounded at each end, 1-septate, occasionally 2-septate, smooth, brown, with a dark band at the septum, $9-13 \times 4-5\mu\text{m}$.

On decorticated wood, Tuskegee National Forest, Macon County, Alabama, June 5, 1979, G. Morgan-Jones, AUA.

Chalara alabamensis Morgan-Jones and Ingram, Mycotaxon 4: 489, 1976 (Fig. 3).

Colonies effuse, hypophyllous, dark brown, velutinous. Mycelium partly superficial, partly immersed in the substratum; immersed mycelium composed of branched, septate, subhyaline, $1.5-2\mu\text{m}$ wide hyphae, superficial mycelium composed of swollen, pale brown, somewhat thick-walled hyphal cells. Conidiophores macronematous, mononematous, phialidic, solitary, scattered or gregarious, simple, erect, straight, smooth, arising directly from cells of the superficial mycelium or from short basal cells, $46-87\mu\text{m}$ long. Conidiogenous cells monophialidic, lageniform, pale brown, $40-82 \times 3-7\mu\text{m}$, with a subcylindric venter, $14-17 \times 6-7\mu\text{m}$, and a long cylindrical collarette which attenuates very gradually towards the apex, $30-53 \times 3-4\mu\text{m}$, transition from venter to collarette gradual. Conidia enteroblastic, endogenous, produced in basipetal chains, cylindrical, 1-septate, hyaline, smooth, truncate at each end, lacking a basal marginal frill, $15-18 \times 2-2.5\mu\text{m}$.

On dead leaves of *Quercus nigra* L., Chewacla State Park, Lee County, Alabama, April 1976, E. G. Ingram, AUA.

Chloridium olavaeforme (Preuss) W. Gams and Holubová-Jechová, Studies in Mycology 13: 31, 1976 (Fig. 4).

= *Gongromeriza olavaeformis* Preuss, Linnaea 24: 106, 1851.

= *Catenularia heimi* Mangelot, Rev. Gén. Bot. 59: 445, 1952.

Colonies effuse, thin, greenish-black, hairy. Mycelium mostly immersed in the substratum, sometimes partly superficial, composed of branched, septate, smooth, pale brown to brown, $2-3.5\mu\text{m}$ wide hyphae. Conidiophores macronematous, mononematous, erect, straight or, more frequently, somewhat flexuous, simple, cylindrical, septate, smooth, pale to mid brown, becoming progressively paler and attenuating gradually towards the apex, determinate or occasionally proliferating percurrently once or twice, distinctly swollen and frequently bulbous at the base, $23-78 \times 3-4\mu\text{m}$. Conidiogenous cells monophialidic, terminal, integrated, more or less cylindrical, tapering very gradually and bearing a cupulate collarette at the base of which is located the conidiogenous locus. Conidia enteroblastic, simple, unicellular, subhyaline, smooth, short-cuneate, formed in slimy masses, $2.5-3 \times 1.5-2\mu\text{m}$.

Anamorph of *Chaetosphaeria myriocarpa* (Fr.) C. Booth.

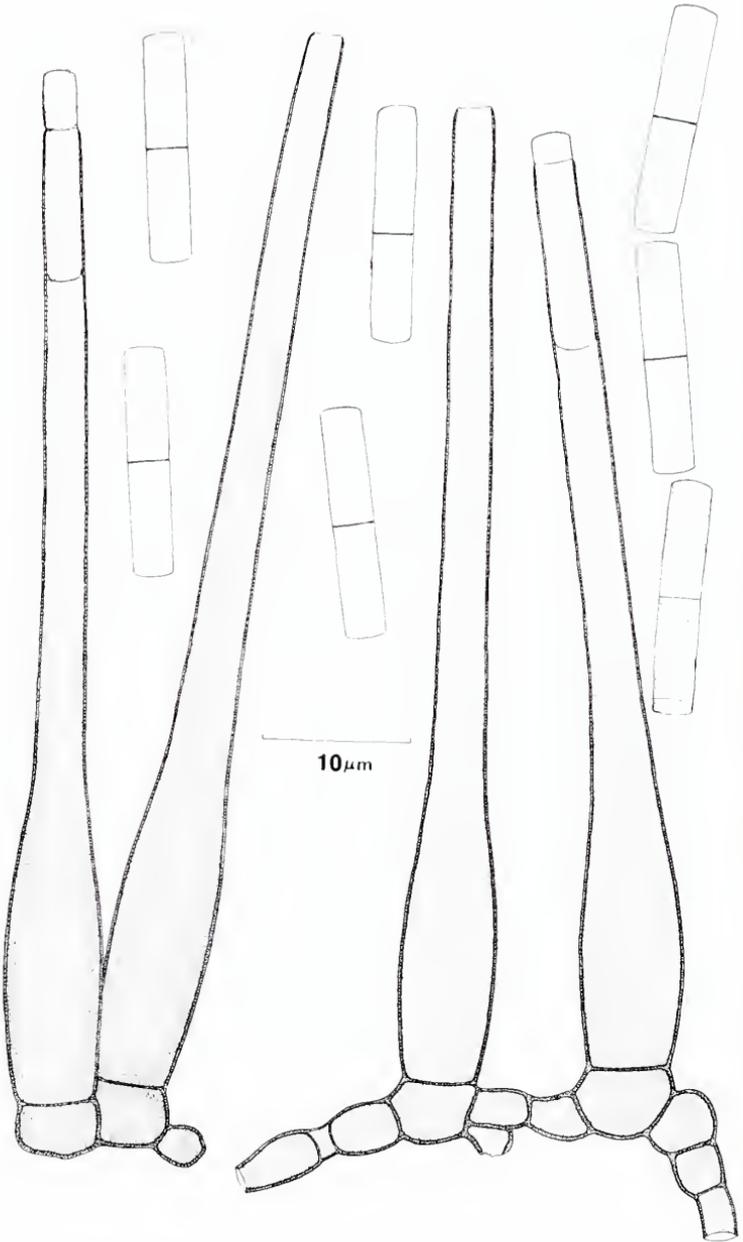


Figure 3. *Chalara alabamensis*

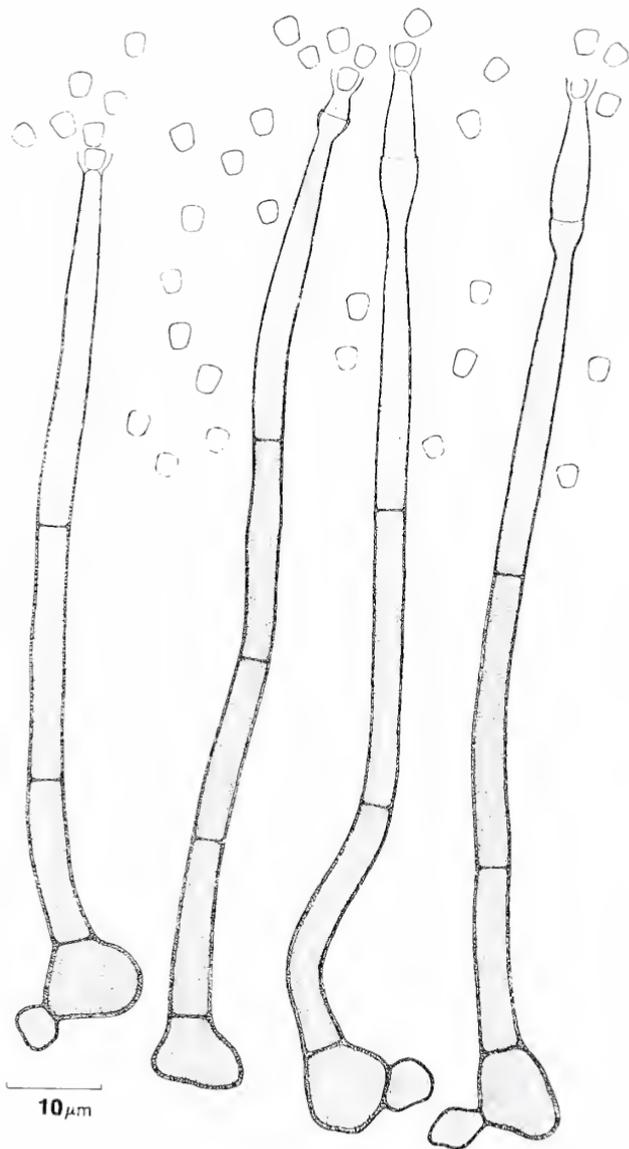


Figure 4. *Chloridium claviforme*

Fungi of Alabama. IX.

On rotten wood, Chewacla State Park, Lee County, Alabama, March 21, 1978, G. Morgan-Jones, AUA; on acorn cup of *Quercus* sp., Chewacla State Park, Lee County, Alabama, May 18, 1979, G. Morgan-Jones, AUA.

Chloridium lignicola (Mangenot) W. Gams and Holubová-Jechová, Studies in Mycology 13: 37, 1976 (Fig. 5).

= *Bisporomyces lignicola* Mangenot, Rev. Mycol. 18: 136, 1953.

Colonies effuse, thin, greenish-black, hairy. Mycelium mostly immersed in the substratum, sometimes partly superficial, composed of branched, septate, smooth, pale brown to subhyaline, 2-3 μ m wide hyphae. Conidiophores macronematous, mononematous, erect, straight or somewhat flexuous, simple, cylindrical, septate, smooth, midbrown to pale brown, becoming progressively paler and attenuating gradually towards the apex, determinate or occasionally proliferating percurrently, 60-170 \times 3-4 μ m. Conidiogenous cells monophialidic, terminal, integrated, more or less cylindrical, tapering gradually and bearing a cupulate collarette at the apex at the base of which is located the conidiogenous locus; often with two conidia remaining within the collarette. Conidia enteroblastic, simple, unicellular, hyaline, smooth, oblong to short-ellipsoidal, 4-5 \times 1.5-2 μ m.

On decorticated wood, off Rt. 50, 5 mi. south of Lafayette, Chambers County, Alabama, July 26, 1979, G. Morgan-Jones, AUA.

Relatively few collections have been made of this taxon. There are two previous records made in the United States at Alleghany State Park, New York, by G. L. Hennebert in 1961 (Gams and Holubová-Jechová, 1976). A second collection is housed at AUA; on rotten wood, Golden Gate Highlands National Park, Orange Free State, South Africa, March 14, 1979, R. C. Sinclair.

Corynespora smithii (Berk. and Br.) M. B. Ellis, Mycol. Pap. 65: 3, 1957 (Fig. 6).

= *Helminthosporium smithii* Berkeley and Broome, Ann. Mag. Nat. Hist. 2: 97, 1851.

Colonies effuse, dark brown to black, velvety. Mycelium partly superficial, partly immersed in the substratum, composed of branched, septate, brown to subhyaline, smooth, 2-6 μ m wide hyphae. Stromata present, mostly immersed, pseudoparenchymatous. Conidiophores macronematous, mononematous, erect, straight or slightly flexuous, simple, cylindrical, septate, smooth, pale brown to dark brown, arising singly or in groups from superficial hyphae or from stromatic cells, sometimes proliferating percurrently, 100-390 \times 6-11 μ m. Conidiogenous cells monotretic, integrated, terminal, cylindrical or somewhat doliform if resulting from a percurrent proliferation. Conidia solitary or, more rarely, in a short chain, simple, septate (pseudosepta), pale brown to brown, dark brown at the basal scar, smooth, more or less cylindrical but tapering very gradually towards the rounded apex, truncate at the base, 80-120 \times 12-18 μ m, 6-8 μ m side at the extreme base.

Isolated from *Buxus sempervirens* L., Wetumpka, Elmore County, Alabama, May 1979, G. W. Karr Jr., AUA.

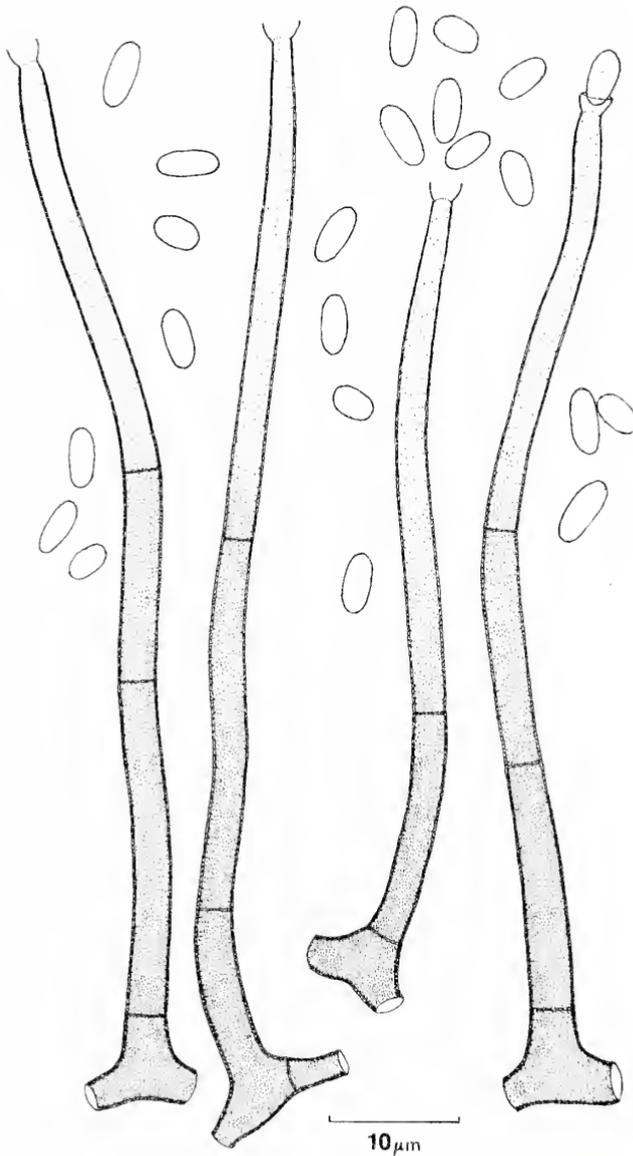


Figure 5. *Chloridium lignicola*

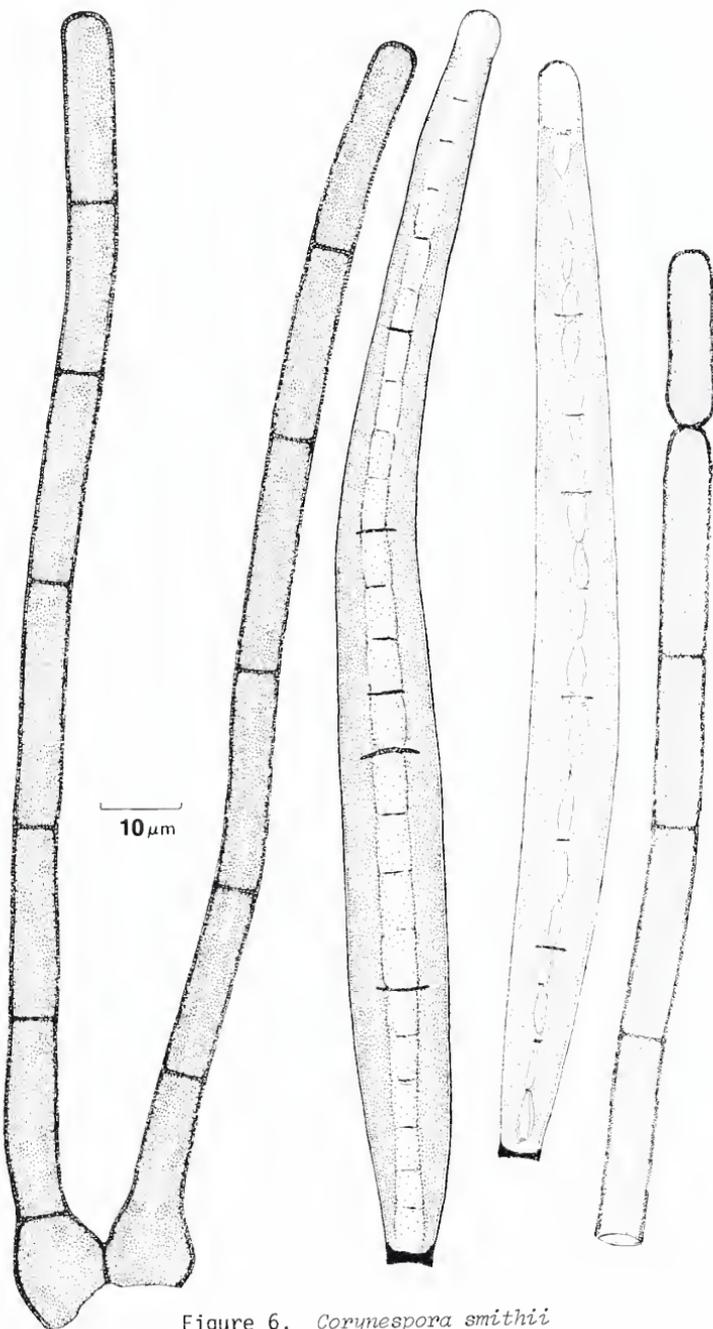


Figure 6. *Corynespora smithii*

Spadicoides atra (Corda) Hughes, Can. J. Bot. 36: 805, 1958 (Fig. 7).
= *Psilonia atra* Corda, Icon. Fung. 4: 27, 1840.

Colonies effuse, black, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of branched, septate, subhyaline to midbrown, 1.5-3 μ m wide hyphae. Conidiophores macronematous, mononematous, solitary or in groups of a few, simple, erect, straight or slightly flexuous, more or less cylindrical, smooth, septate, brown to pale brown, becoming progressively paler towards the apex, 70-370 \times 3-4.5 μ m. Conidiogenous cells polytretic, integrated, terminal and intercalary, determinate, slightly constricted at the separating septa, conidiogenous loci apparent as minute pores. Conidia solitary, dry, acropleurogenous, simple, oblong to ellipsoidal, unicellular, smooth, pale brown to brown, 4-6.5 \times 2.5-4 μ m.

On decorticated wood, off Rt. 50, 5 mi. south of Lafayette, Chambers County, Alabama, July 26, 1979, G. Morgan-Jones, AUA.

Spadicoides canadensis Hughes, Fungi Canadenses No. 9, 1973 (Fig. 8).

Colonies effuse, black, thin, hairy. Mycelium mostly immersed in the substratum, composed of branched, septate, subhyaline to midbrown, 1.5-3 μ m wide hyphae. Conidiophores macronematous, mononematous, scattered, solitary or in groups of a few, simple, erect, straight or slightly flexuous, more or less cylindrical, smooth, septate, 50-180 \times 3-3.5 μ m. Conidiogenous cells polytretic, integrated, terminal and intercalary, determinate, conidiogenous loci apparent as minute pores. Conidia solitary, dry, acropleurogenous, simple, ellipsoidal, 1-septate, slightly constricted at the septum, smooth, pale brown to brown, thick-walled, 9-12 \times 5-6 μ m.

On decorticated wood, off Rt. 50, 5 mi. south of Lafayette, Chambers County, Alabama, July 26, 1979, G. Morgan-Jones, AUA.

This taxon was described from a single collection made in 1958 on decaying wood of *Populus* sp., at South March, Ontario, Canada. Subsequently two records of it have been made in upstate New York at Letchworth State Park, Wyoming County, and near Lewis, Essex County (Wang, 1976).

Sporidesmium brachypus (Ell. and Everh.) Hughes, Can. J. Bot. 36: 807, 1958 (Fig. 9).

- = *Helminthosporium brachypus* Ellis and Everhart, apud Millsp. and Nuttall, Publ. Field Col. Mus. Bot. 1: 92, 1896.
- = *Sporidesmium deightonii* M. B. Ellis, Mycol. Pap. 70: 26, 1958.

Colonies effuse, blackish-brown to black. Mycelium mostly immersed in the substratum, composed of branched, septate, pale brown to brown, smooth, 2-4.5 μ m wide hyphae. Conidiophores macronematous, mononematous, solitary or in small caespitose groups, erect, straight or slightly flexuous, simple, cylindrical, conico-truncate at the apex, base somewhat swollen, brown, septate, smooth, occasionally proliferating percurrently, 32-65 \times 5-7 μ m. Conidiogenous cells monoblastic, integrated,

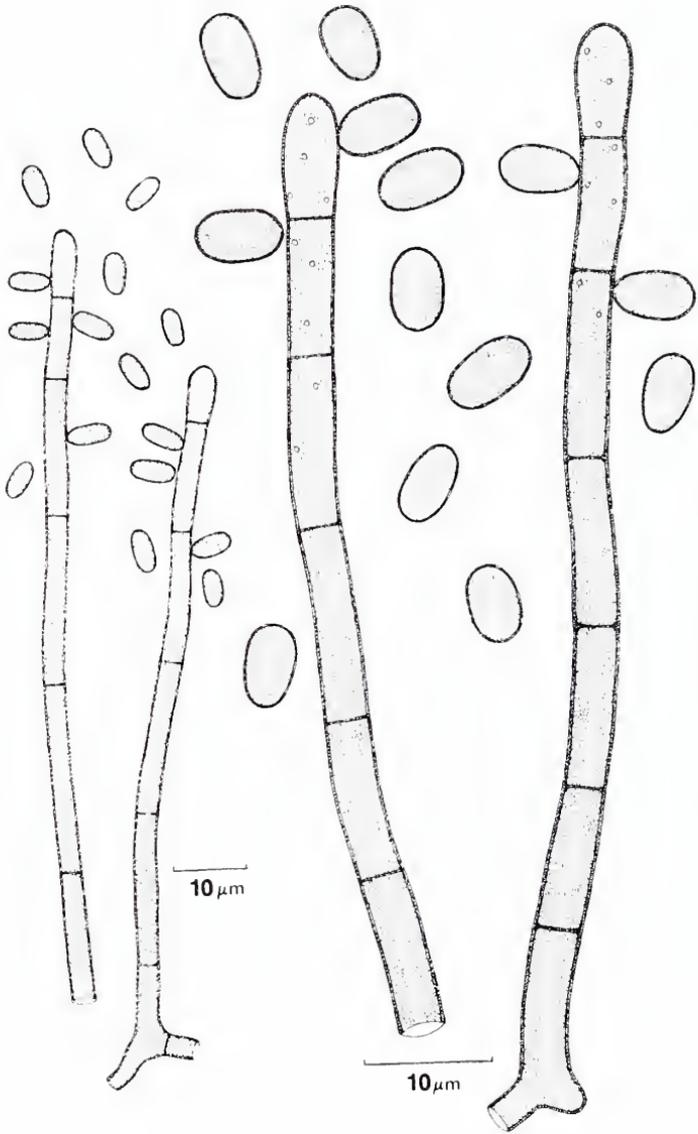


Figure 7. *Spadicoides atra*

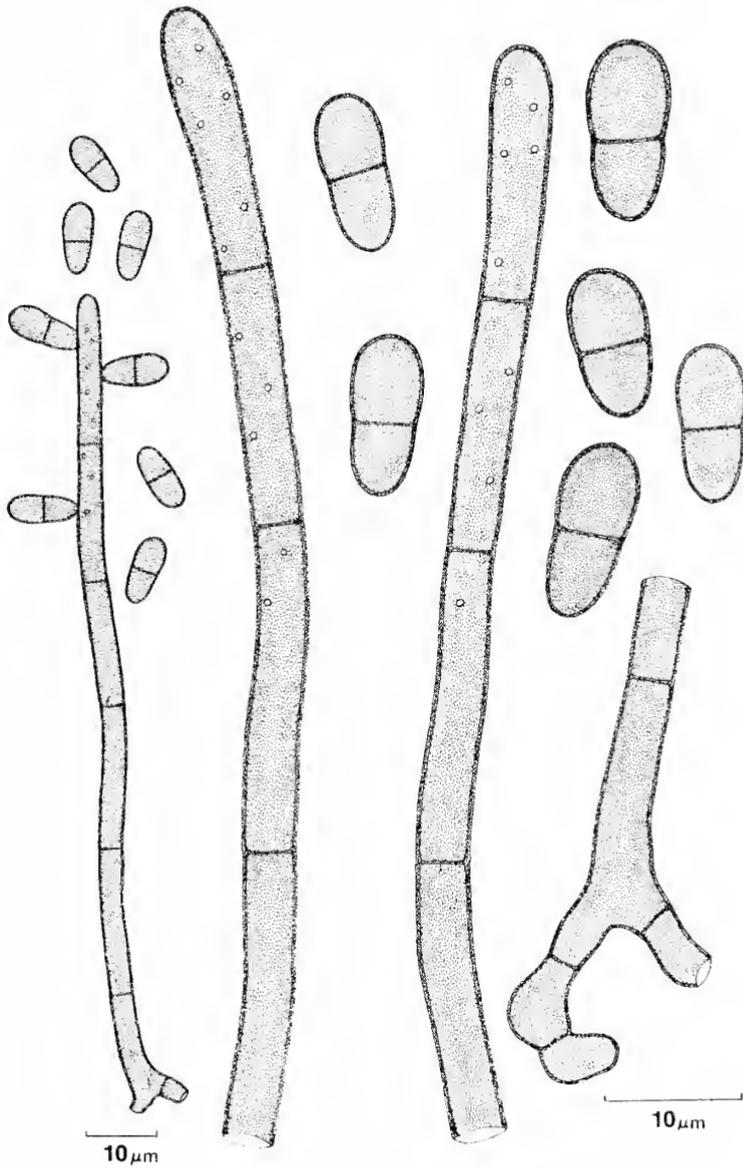


Figure 8. *Spadicoides canadensis*

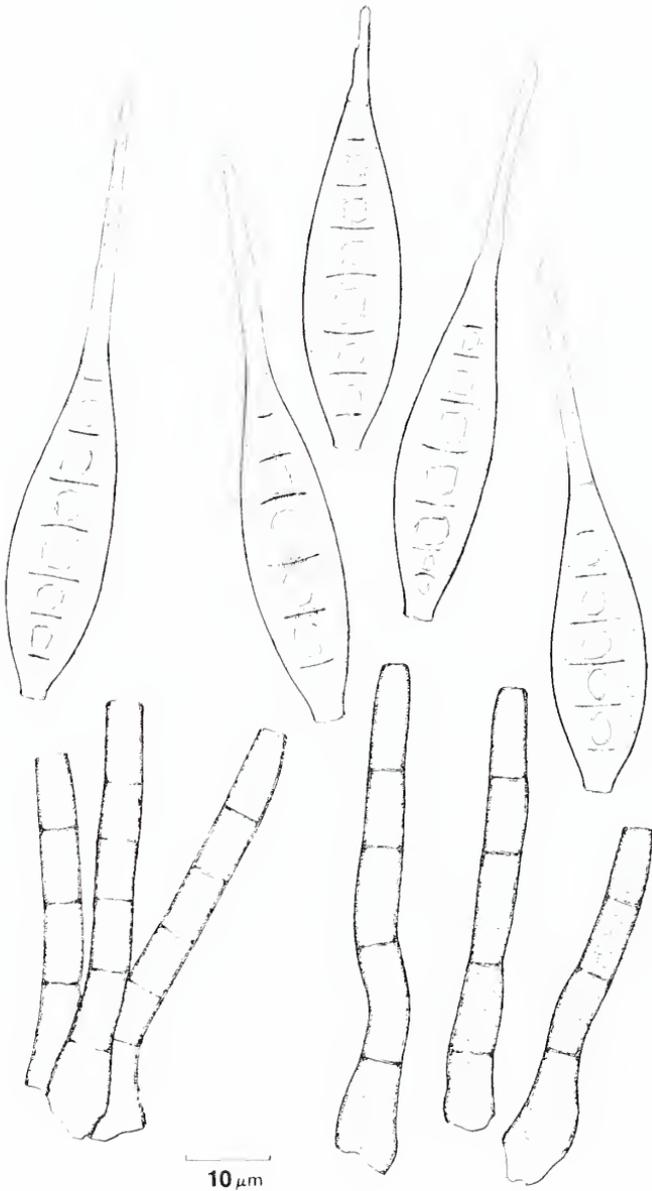


Figure 9. *Sporidesmium brachypus*

terminal, determinate or percurrent. Conidia solitary, dry, acrogenous, simple, straight or slightly curved, obclavate, rostrate, pale brown, smooth, septate (pseudosepta, frequently with a thickened septal pore area), distinctly truncate at the base, $50-82 \times 10-14\mu\text{m}$, tapering to $1.5-2\mu\text{m}$ near the apex, $3.4-4.5\mu\text{m}$ wide at the base.

On decorticated wood, Chewacla State Park, Lee County, Alabama, May 1978, G. Morgan-Jones, AUA; on decayed fruit of *Castanea* sp., Auburn University Arboretum, Auburn, Lee County, Alabama, May 29, 1979, T. Matsushima, AUA.

Sympodiella laxa Subramanian and Vittal, Can. J. Bot. 51: 1131, 1973 (Fig. 10).

Colonies effuse, thin. Mycelium mostly immersed in the substratum, composed of branched, septate, smooth, pale brown to hyaline, $1.5-4\mu\text{m}$ wide hyphae. Conidiophores macronematous, mononematous, scattered, simple or branched, erect, straight or flexuous, geniculate in the conidiogenous zone, sympodial, smooth, cylindrical, brown to pale brown, generally paler towards the apex which is subhyaline, $400-980 \times 5-7.5\mu\text{m}$. Conidiogenous cells discrete, solitary, cylindrical, terminal or originating as lateral branches of the main stipe. Conidia arthric, catenate, dry, simple, cylindrical with truncate ends, hyaline, smooth, $1-4$ -septate, $20-58 \times 6-8.5\mu\text{m}$.

On dead leaves of *Quercus* sp., Auburn University Forestry Plots, Auburn, Lee County, Alabama, May 18, 1978, R. C. Sinclair, AUA.

Sympodiella laxa was described from a collection on leaves of an unidentified dicotyledon found in litter at Anantagiri, Andhra Pradesh, India. Matsushima (1975) reported a collection on dead leaves of *Daphniphyllum macropodium* from Tokyo, Japan. The Alabama collection represents the third record of it and the first from North America.

REFERENCES

- Gams, W. and V. Holubová-Jechová. 1976. *Chloridium* and some other dematiaceous hyphomycetes growing on decaying wood. Studies in Mycology No. 13. Centraalbureau voor Schimmelcultures. 1-99.
- Hughes, S. J. 1958. Revisiones hyphomycetum aliquot cum appendice de nominibus rejiciendis. Can. J. Bot. 36: 727-836.
- Matsushima, T. 1975. Icones microfungorum a Matsushima lectorum. Kobe. Published by the author.
- Wang, C. J. K. 1976. *Spadicoides* in New York. Mem. N.Y. Bot. Gard. 28: 218-224.

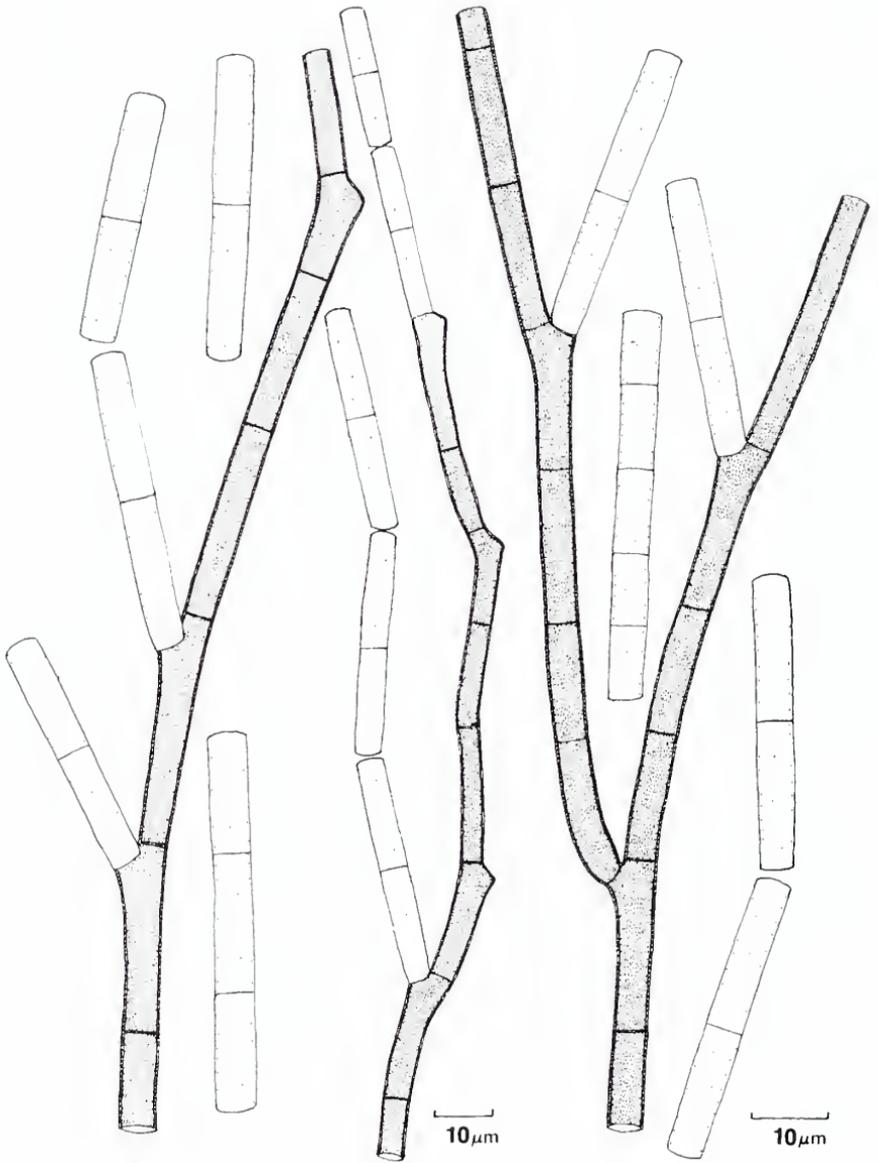


Figure 10. *Sympodiella laxa*

ADDITIONAL DISTRIBUTIONAL RECORDS OF THE PRAIRIE VOLE
(*Microtus ochrogaster*) FROM NORTHERN ALABAMA¹

Douglas S. Allen² and Julian L. Dusi
Department of Zoology-Entomology
Auburn University
Auburn, AL 36830

The prairie vole (*Microtus ochrogaster*) was first collected in the southeast at a site near Reelfoot Lake, Lake County, Tennessee (Howell, Proc. Biol. Soc. Wash., 23: 23-34, 1910). Recent studies have indicated a gradual movement of the species to the southeast. Dimmick (J. Mamm., 50: 126, 1969) extended the recorded range in Tennessee to the eastern rim of the Cumberland Plateau. Severinghaus and Beasley (J. Tenn. Acad. Sci., 48: 129-133, 1973) found voles to be common throughout western Tennessee, except for the southernmost tier of counties. Six voles, AUMV (Auburn University Vertebrate Museum) 4-1284, 1285, and 4-1375 - 1378, were collected by T. W. French at a site 3.2km south of Saltillo, Hardin County, Tennessee, near the Mississippi border in 1975 (unpublished).

The original records of the prairie vole in Alabama were three specimens trapped on the northern shore of the Tennessee River, 20km south of Huntsville, Madison County, in January 1955 (Whitaker and Zimmerman, J. Mamm., 49: 328, 1968). Unpublished accounts are available from Jackson County. T. R. Smith trapped 257 individuals 5km southeast of Hollywood, in 1974, and T. R. Jones collected one adult female, AUMV 4-1563, 6.5km east of Scottsboro, in October 1976.

During the course of a study conducted by the senior author in northern Alabama from 20 June through 4 August, 1977, 14 prairie voles were collected from six additional localities:

AUMV 4-1590 - 1593. Four sub-adults, three males and one female, collected 16.2km southwest of Florence, Lauderdale County, 22-24 June.

AUMV 4-1594, 1595. Two adults, a male and a female, collected 6.8km east-northeast of Lexington, Lauderdale County, 20-30 June.

AUMV 4-1596 - 1598. Three females, two adults and one sub-adult, collected 16km west-southwest of Athens, Limestone County, 7-8 July.

¹Manuscript received 18 September 1979; accepted 8 February 1980.

²Present Address: Department of Zoology, The Ohio State University, Columbus, Ohio 43210.

Additional Distributional Records of the Prairie Vole

AUVM 4-1599 - 1601. Two females, one adult and one sub-adult, and one adult male, collected 13.5km west of Tuscombia, Colbert County, 20-21 July.

AUVM 4-1602. One sub-adult male collected 15km southeast of Moulton, Lawrence County, 27 July.

AUVM 4-1603. One adult female collected 12km northwest of Decatur, Morgan County, 2 August.

These records, together with those from Madison and Jackson counties, indicate that the range of the prairie vole now includes the majority of the Tennessee Valley and Chert Belt regions (Mount, The reptiles and amphibians of Alabama, p. 9, 1975) of northern Alabama. Trapping conducted south of the Tennessee Valley, in the Appalachian Plateau and Fall Line Hill regions, failed to produce any additional specimens.

All voles were collected in either unmowed field-edge, or oldfield successional sites. The vegetation at these sites consisted of 60-90% grasses and 10-40% forb species. Major grass species included fescue (*Festuca arundinacea*), johnsongrass (*Sorghum halepense*), broomsedge (*Andropogon virginicus*), bermudagrass (*Cynodon dactylon*), orchardgrass (*Dactylis glomerata*) and foxtail (*Setaria* spp.). Forb species included lespedeza (*Lespedeza* spp.), fleabane (*Erigeron* spp.), goldenrods (*Solidago* spp.), ragweed (*Ambrosia* spp.) and blackberry (*Rubus* spp.). Trees, when present, were found only at the periphery of the sites.

We thank John D. Harder, The Ohio State University, Columbus, Ohio, for his review of the preliminary draft of this report.

DETERMINATION OF DISTANCE TO BE MOVED FROM EXPERIMENT
TO EXPERIMENT WHEN EXPLORING A RESPONSE SURFACE¹

G. S. Hines and J. N. Hool
Department of Industrial Engineering
Auburn University
Auburn, AL 36830

Abstract. Two strategies were developed and tested to determine the distance to be moved from experiment-to-experiment in response surface exploration. Both strategies were tested on a simple response surface using a previously developed computerized response surface analysis simulator. Both strategies performed reasonably well under test conditions.

1. INTRODUCTION

Response surface analysis (RSA) is essentially a set of mathematical and statistical methods used in research of solutions of certain types of problems which are pertinent to scientific or engineering processes. Its most frequent application has been in industrial research, particularly in processes where a large number of variables influence the yield of a system. For example, the response might be the yield of a certain chemical resulting from variations with temperature, the percentage of inert solvent, and pressure.

As a sequel to an earlier RSA publication in *The American Statistician* by Maghsoodloo and Hool (1976), this paper presents the development and testing of strategies for determining the distance to be moved from one experiment center to the next. The RSA simulator reported by Maghsoodloo and Hool (1976) was used as a mechanism for conducting numerous simulated experiments that involved deploying the subject strategies to explore a particular response surface. Throughout this paper the familiar methodology of RSA discussed extensively in Box and Wilson (1951), Box and Youle (1955), Davies (1953), Duncan (1965), Hicks (1964), Hunter (1958) and Meyers (1971) is assumed. The strategies investigated determine the distance to be moved from an initial experiment center to the center of a second experiment, and the distance to be moved from the center of a second experiment to the center of a third experiment. An extensive computer search of literature revealed no similar studies.

2. METHODOLOGY OF RSA

Response surface analysis involves determination of the optimum of a response surface, η , dependent on certain input variables X_1, X_2, \dots, X_k .

¹Manuscript received 1 November 1979; accepted 7 January 1980.

Exploring a Response Surface

In the example cited earlier, the chemical engineer is interested in the yield, η , of a certain chemical reaction. This yield is dependent on the reaction temperature, X_1 , concentration of one reactant, X_2 and pressure, X_3 . In general, the relationship is described by

$$\eta = f(X_1, X_2, \dots, X_k) \quad (2.1)$$

where the form of f is unknown but assumed reasonably well approximated by a low-order polynomial. The controllable variables are assumed to be quantitative and continuous and measured with negligible error.

It is also assumed that the response surface has a single maximum (minimum) in the range of feasible variation of the independent variables and that other local maxima (minima) do not occur in the immediate neighborhood of the overall maximum (minimum). The task of the experimenter is to determine, using the most economical strategy, (1) a suitable approximating function for the purpose of predicting future response, and (2) what values of the independent variables are optimum as indicated by the response.

The success of RSA depends on the approximation of f by a first, second, or possibly third degree polynomial in a feasible region of the independent variables. For a region where little curvature of f is present, an approximation given in terms of k design variables is

$$\eta = \beta_0 + \beta_1 X_1 + \dots + \beta_k X_k \quad (2.2)$$

where the coefficients $\beta_0, \beta_1, \dots, \beta_k$ are estimated from data collected by the experimenter. Otherwise, the experimenter might use the second degree approximation

$$\eta = \beta_0 + \sum_{i=1}^k \beta_i X_i + \sum_{i=1}^k \beta_{ii} X_i^2 + \sum_{\substack{i,j \\ i < j}} \beta_{ij} X_i X_j. \quad (2.3)$$

Two excellent references for further understanding of response surface experimentation are Davies (1953) and Hunter (1958).

3. LIMITATIONS AND APPROACH

The response surface described by equation (3.1) was used for this investigation.

$$\eta = 1 - X_1^2 - X_2^2. \quad (3.1)$$

This surface has a maximum value of unity occurring at $X_1 = X_2 = 0$. Some of its contours are shown in Figure 1 on the X_1, X_2 plane. An observed value of the response variable is given by

$$y = 1 - X_1^2 - X_2^2 + e \quad (3.2)$$

where e was specified to be $N(0, .05)$. Finally, the experimental design chosen for all RSA simulations was a two-replication 2×2 factorial with a center point. When fitting a first-order equation of the form

$$\hat{y} = b_0 + b_1X_1 + b_2X_2 \quad (3.3)$$

this design has a breakdown of sources of variation and degrees of freedom shown below.

Degrees of Freedom in Analysis
of 2×2 Factorial Design

Source	DF
Total	10
b_0	1
b_1	1
b_2	1
Residual	7
Lack of Fit	2
Error	5

Spacing for all RSA simulation experiments was 0.2 (arrived at through preliminary RSA experimentation using (3.1)). For example, a 2×2 experiment with points at (-4,3), (-3.9,2.9), (-4.1,2.9), (-4.1,3.1) and (-3.9, 3.1) has spacing of 0.2

To assess the effectiveness of the subject strategies, a total of 1,500 sequences of first-order simulated experiments was conducted from initial experiment centers located 5, 10 and 15 units distance from the optimum (500 sequences were conducted from each distance). The distances corresponded to respective initial design centers with X_1, X_2 coordinates of (-4,3), (-8,6) and (-12,9). These were chosen because none lies on an axis where one of the variables (X_1, X_2) attains its optimal value or is equidistant from either the X_1 or X_2 axis. Each sequence employed an initial strategy (to be discussed) to determine the distance to be moved from the initial experimental design center to the center of a second design. Then from each second design center a second strategy (to be discussed) was employed to determine the distance to be moved to the center of a third design. For each of the 1,500 sequences of experiments the computer simulator RSAP (Maghsoodloo and Hool, 1976) was used to fit a first-order equation at the initial design center and, also, the second design center. RSAP was, however, integrated into a larger computerized system that executed the subject strategies and collected statistical data to be used in assessing the effectiveness of the strategies. A discussion of RSAP appears in the Appendix.

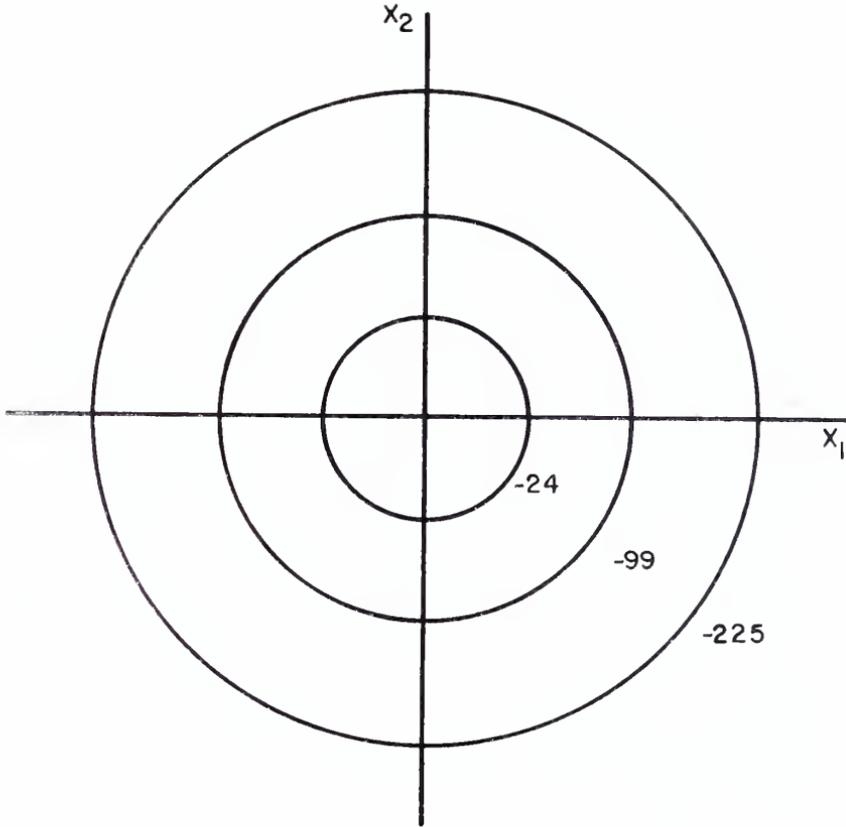


Figure 1. Response surface contours.

4. FIRST-MOVE STRATEGY

This strategy uses only information obtained from an initial first-order experiment to determine the distance to be moved from the initial design center to the center of a second design. The distance, d_1 , to be moved is given by

$$d_1 = \frac{\begin{vmatrix} b_{11} \\ b_{21} \end{vmatrix}}{\sqrt{\frac{|b_{11}| + |b_{21}|}{2}}} \quad (4.1)$$

where b_{11} and b_{21} are first-order equation regression coefficients on X_1 and X_2 , respectively (the second subscript indicates the initial experiment). Equation (4.1) can be used whenever the initial design center with coordinates (X_{11}, X_{21}) is such that neither X_{11} nor X_{21} are near the respective optimal values of X_1 and X_2 . When b_{11} and/or b_{21} indicate statistical insignificance of the respective first-order equation parameters β_1 and β_2 , equation (4.1) is inappropriate. Further, if

b_{11} and/or b_{21} assume values in an interval $(-1,1)$, equation (4.1) may suggest relocation of a second design center at too great a distance from the initial design center (X_{11}, X_{21}) . Equation (4.1) is based on the conservative premise that d_1 be inversely proportional to b_{21}/b_{11} (the slope of a line perpendicular to a response surface contour at (X_{11}, X_{21})), and that d_1 be a function of the square root of the average of $|b_{11}|$ and $|b_{21}|$. Similar results could be obtained using d_1 as a function of the square root of the average of $(b_{11})^2$ and $(b_{21})^2$.

To determine the center of a second design with coordinates (X_{12}, X_{22}) located d_1 units from (X_{11}, X_{21}) along a path of steepest ascent, the familiar Pythagorean theorem is used. The magnitude of change in X_1 is given by

$$X_{12} - X_{11} = \sqrt{\frac{d_1^2}{1 + (b_{21}/b_{11})^2}} \quad (4.2)$$

and the magnitude of change in X_2 is given by

$$X_{22} - X_{21} = \frac{b_{21}}{b_{11}} (X_{12} - X_{11}). \quad (4.3)$$

Directional change (i.e. increase or decrease) in X_1 and X_2 is, of course, determined by the signs of b_{11} and b_{21} , respectively.

5. SECOND-MOVE STRATEGY

This strategy uses information obtained from an initial and a second first-order experiment to determine the distance to be moved from the second design center to the center of a third design. It is assumed that a satisfactory first-order fit has been obtained with the initial and second design. This strategy is based on the fact that as a region of optimality is approached using the steepest ascent method, the regression coefficients b_1 and b_2 in (3.3) approach zero, and a functional relationship exists between b_1 and X_1 (or b_2 and X_2). Utilizing information obtained from an initial and second design, a linear projection of b_1 (or b_2) onto the X_1 (or X_2) axis where b_1 (or b_2) equals zero is made. This is illustrated in Figure 2 where X_{13} is the X_1 coordinate for the center of the third design, and b_{12} is the first-order regression coefficient on X_1 obtained from the second experiment ($X_{11} < X_{12}$ in this illustration).

The distance to be moved along X_1 is, of course, $X_{13} - X_{12}$. If this method is used to locate X_{13} , then X_{23} (the X_2 coordinate for the center of a third design) can be determined, using steepest ascent procedures, from

$$X_{23} - X_{22} = (X_{13} - X_{12}) \frac{b_{22}}{b_{12}} \quad (5.1)$$

Exploring a Response Surface

where $x_{22} = x_2$ coordinate for the center of a second design
 b_{22} = first-order regression coefficient on x_2 obtained from the second experiment.

The distance, d_2 , to be moved from (x_{12}, x_{22}) to (x_{13}, x_{23}) is therefore

$$d^2 = \sqrt{(x_{13} - x_{12})^2 [1 + b_{22}^2/b_{12}^2]}. \quad (5.2)$$

Alternatively, x_{23} could be located using a linear projection method (Figure 2), then x_{13} could be located using the equivalent of (5.1). If b_{12} and/or b_{22} indicate statistical insignificance of respective first-order equation parameters β_1 and β_2 , then at most one of the third design center coordinates (x_{13}, x_{23}) must be located.

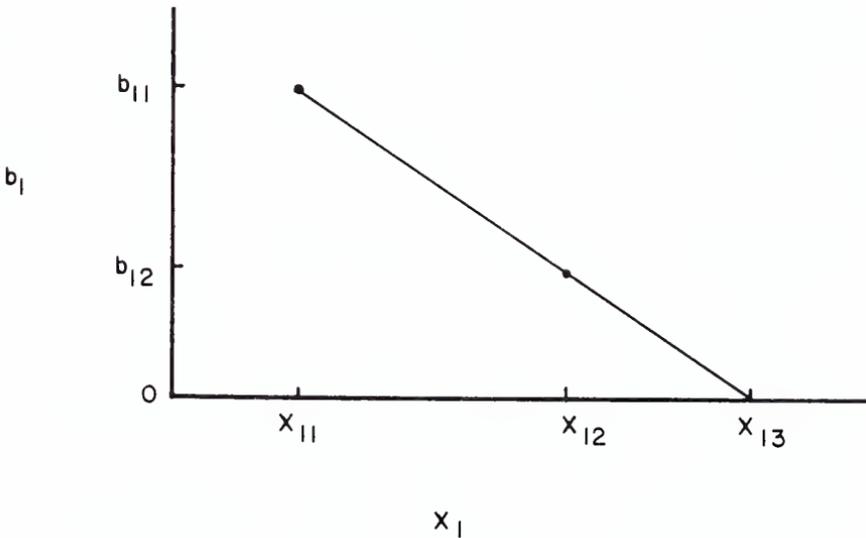


Figure 2. Linear projection of b_1 onto x_1 .

6. RESULTS: FIRST-MOVE STRATEGY

Table 1 summarizes the percent of the distance moved toward optimum from an initial design center. Table 1 contains a frequency count (and equivalent percentages) for the relative length of moves from the initial design center, where the relative lengths are broken down into the indicated percentage classes in column 1.

Table 1. Frequency count of distance moved using first-move strategy.

Percent Distance Moved Toward Optimum	Distance of Initial Design Center from Optimum		
	5	10	15
0 < % < 25	7 (1.4%)	54 (10.8%)	461 (92.2%)
25 < % < 30	44 (8.8%)	334 (66.8%)	39 (7.8%)
30 < % < 40	212 (42.4%)	112 (22.4%)	0 (.0%)
40 < % < 50	206 (41.2%)	0 (.0%)	0 (.0%)
50 < % < 100	31 (6.2%)	0 (.0%)	0 (.0%)
Total	500	500	500

For example, 212 out of 500 (42.4%) second design centers were located within 30% to 40% of the distance between the initial design center that was situated 5 units from the true optimum. Results in Table 1 indicate that as the distance from optimum of initial design centers increases, the first-move strategy locates second design centers proportionately less close to optimum. This is illustrated graphically in Figure 3 which shows a plot of cumulative percent of 500 located second design centers versus percent distance moved toward optimum for each initial distance from optimum (labeled 5, 10, 15). Figure 3 was developed from an ordered listing of each of 500 distances moved from the starting locations.

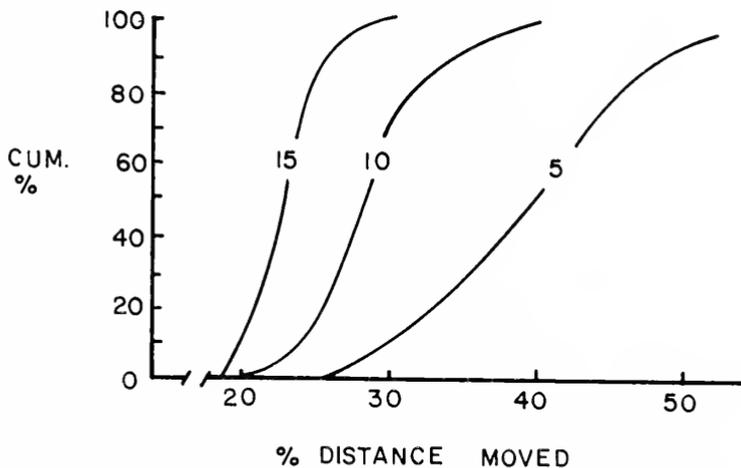


Figure 3. Cumulative percent of second design centers located X% toward optimum.

Exploring a Response Surface

Figures 4, 5 and 6 indicate the accuracy in locating second design centers along a line drawn from initial design centers to optimum. Curvilinear contours shown correspond to relevant accuracy intervals included in Table 1. As would be expected, located second design centers clustered generally around the straight trajectory line connecting the starting coordinate with the optimum coordinate.

7. RESULTS: SECOND-MOVE STRATEGY

Table 2 is a summary of how close to optimum the third design centers were located. Table 2 contains a frequency count (and equivalent percentages) of the number of experiments that were within the indicated percent accuracy intervals, where percent accuracy for a given located third design center was determined as the third design center's distance from optimum expressed as a percent of the initial design center's distance from optimum (i.e. either 5, 10 or 15 units).

Of the 1,500 sequences of experiments conducted, only six located third design centers were further from optimum than the initial design center located five units from optimum. At least 50% of all located third design centers were within 20% of optimum, while at least 70% were within 30% of the optimum.

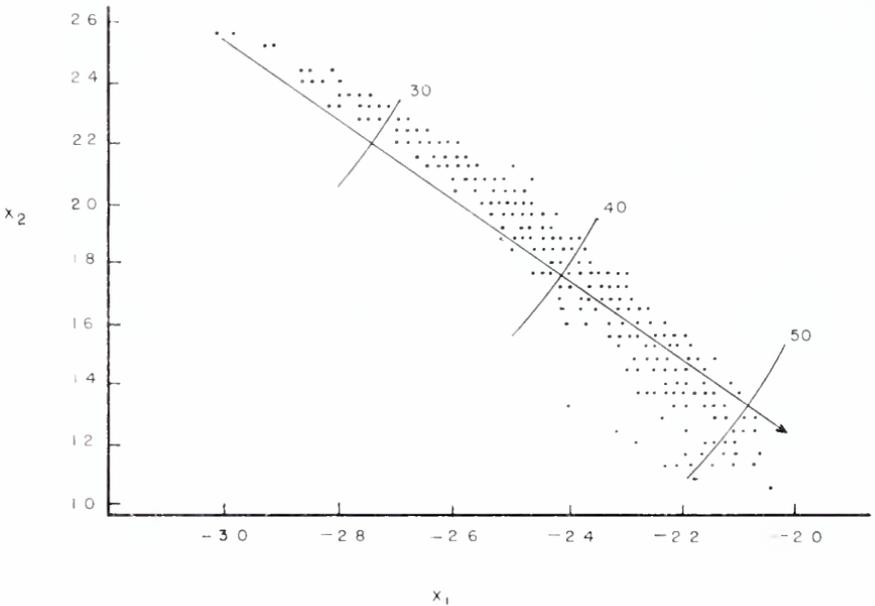


Figure 4. Location of second design centers when initial center was five units from optimum.

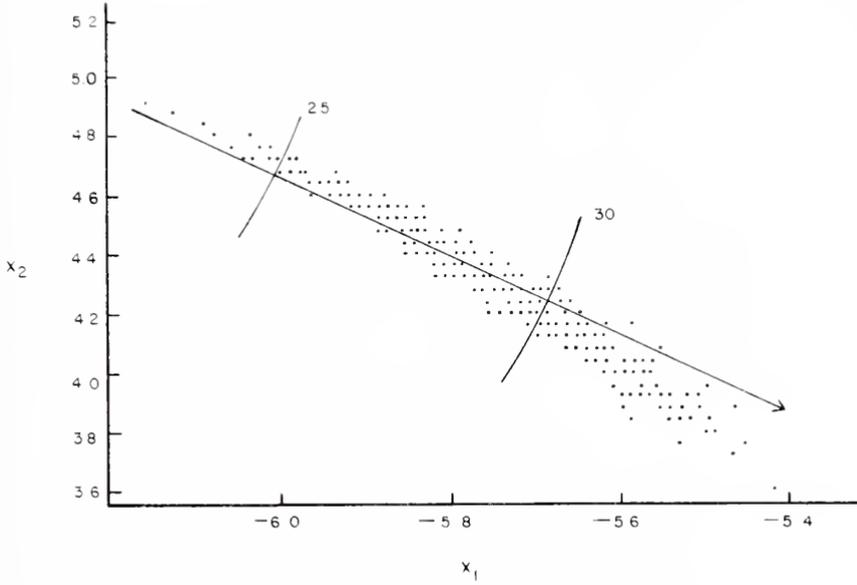


Figure 5. Location of second design centers when initial center was ten units from optimum.

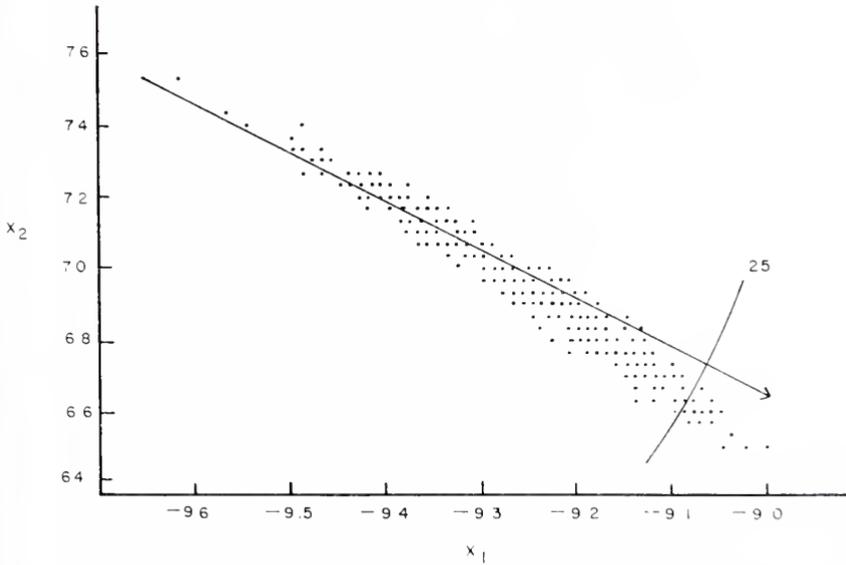


Figure 6. Location of second design centers when initial center was fifteen units from optimum.

Table 2. Accuracy in locating third design centers using second-move strategy.

Percent Accuracy Interval	Distance of Initial Design Center from Optimum		
	5	10	15
50 < % < 100	37 (7.4%)	20 (4.0%)	4 (.8%)
40 < % < 50	16 (3.2%)	16 (3.2%)	3 (.6%)
30 < % < 40	43 (8.6%)	37 (7.4%)	23 (4.6%)
20 < % < 30	115 (23.0%)	79 (15.8%)	71 (14.2%)
10 < % < 20	159 (31.8%)	174 (34.8%)	176 (35.2%)
0 < % < 10	124 (24.8%)	179 (34.8%)	223 (44.6%)
Other	6	0	0
Total	500	500	500

Figures 7, 8 and 9 indicate the accuracy in locating third design centers both along the straight trajectory line connecting the starting coordinate with the optimum coordinate, and with respect to the optimum coordinate. Curvilinear contours shown correspond to relevant accuracy intervals included in Table 2. Located third design centers clustered generally around the trajectory line, and approximately one half were located beyond the optimum coordinate. Judged on the basis of percent accuracy, the second-move strategy produced more accurate results as initial design center distance from optimum increased. Judged on the basis of absolute accuracy, however, the second-move strategy produced more accurate results as initial design center distance from optimum decreased. For all three initial distances from optimum, at least 90% of all sequences of experiments located third design centers within 50% of optimum.

8. SUMMARY AND CONCLUSION

Employment of the first-move and second-move strategies for the response surface in (3.1) located, respectively, second design centers and third design centers which were consistent with steepest ascent method expectations and quickly approached response surface optimum conditions. The fact that located third design centers clustered around optimum conditions is impressive evidence of the strategies' ability to efficiently approach optimum conditions for the simple surface studied. Development of additional strategies, and investigation of first-move and second-move strategies applied to additional response surfaces are subjects for further work.

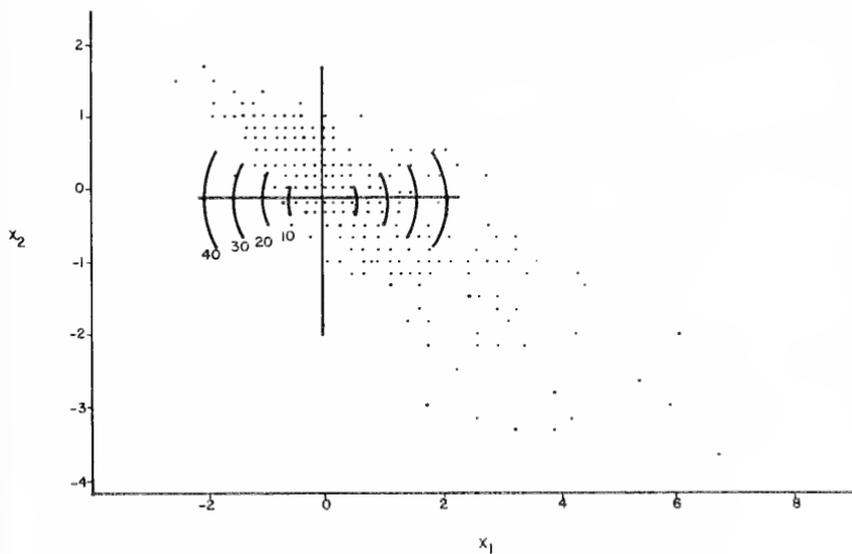


Figure 7. Location of third design centers when initial center was five units from optimum.

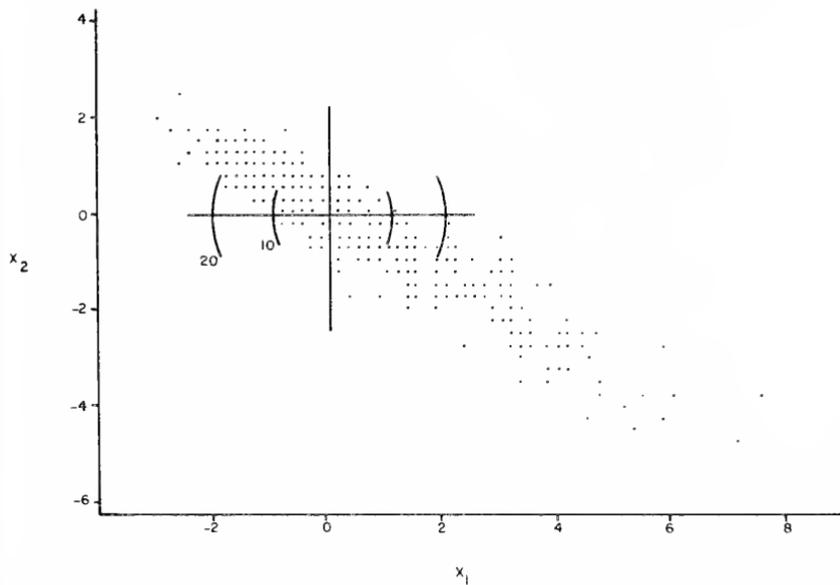


Figure 8. Location of third design centers when initial center was ten units from optimum.

Exploring a Response Surface

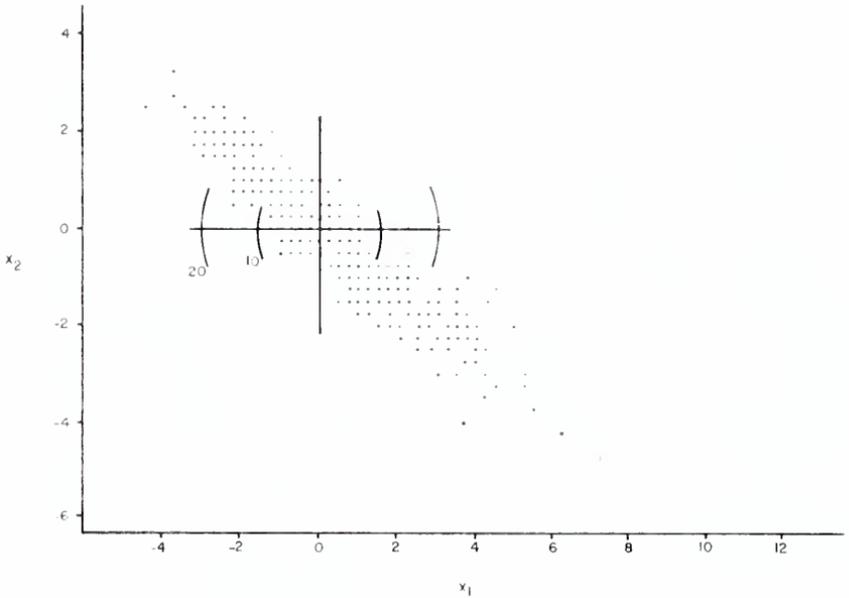


Figure 9. Location of third design centers when initial center was fifteen units from optimum.

LITERATURE CITED

- Box, G. E. P., and Wilson, K. P. (1951), "On the Experimental Attainment of Optimum Conditions," *Journal of the Royal Statistical Society, Series B*, 1-45.
- Box, G. E. P., and Youle, P. V. (1955), "The Exploration and Exploitation of Response Surfaces, II: An Example of the Link Between the Fitted Surface and the Basic Mechanism of the System," *Biometrics*, 11, 287-323.
- Davies, O. L. (1953), *Design and Analysis of Industrial Experiments*, New York: Hafner Publishing Co.
- Duncan, A. J. (1965), *Quality Control and Industrial Statistics*, 3rd Edition, Homewood, Illinois: Richard D. Irwin, Inc.
- Hicks, C. R. (1964), *Fundamental Concepts in the Design of Experiments*, New York: Holt, Rinehart and Winston, Inc.
- Hunter, J. S. (1958-1959), "Determination of Optimum Operating Conditions by Experimental Methods," *Industrial Quality Control*, December-February.

Exploring a Response Surface

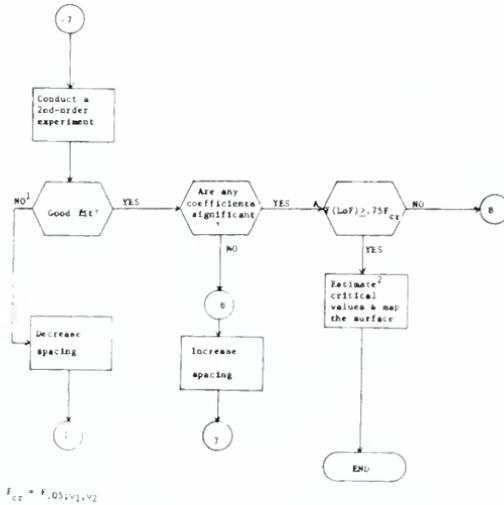


Figure 11. Flowchart of second-order methodology.

NOTES

NOTES

THE JOURNAL
OF THE
ALABAMA ACADEMY
OF SCIENCE

AFFILIATED WITH THE
AMERICAN ASSOCIATION FOR THE
ADVANCEMENT OF SCIENCE

VOLUME 51

APRIL, 1980

NO. 2

EDITOR:

W. H. Mason, General Biology, Auburn University, AL 36849

ARCHIVIST:

R. G. Eaves, Department of History, Auburn University, AL 36849

EDITORIAL BOARD:

R. T. Gudauskas, Chairman, Department of Botany and Microbiology, Auburn University, AL 36849

E. A. Curl, Department of Botany and Microbiology, Auburn University, AL 36849

W. W. Paulder, Department of Chemistry, University of Alabama, University, AL 35486

ADVISORY BOARD:

W. L. Alford, Auburn University

Charles Baugh, Univ. of South Alabama

G. F. Brockman, Univ. Ala., B'ham

R. J. Fornaro, Univ. South Alabama

A. Wayne Lacy, Auburn Univ., Mtgy.

Walker H. Land, Jr., IBM

H. S. Marks, N. E. St. Jr. Col.

M. Miller, Univ. South Alabama

W. W. Paulder, UA, Tuscaloosa

Dan Whitson, Decatur

E. M. Wilson, Univ. South Alabama

The Journal is the official publication of the Alabama Academy of Science, and is indexed in Biological Abstracts, Chemical Abstracts, America: History and Life, and Historical Abstracts.

Publication and Subscription Policies

Submission of Manuscripts. Submit all manuscripts and pertinent correspondence to the EDITOR. Each manuscript will receive two simultaneous reviews. For style details, follow Instruction to Authors, J. Ala. Acad. Sci. 50:96-97, 1979.

Reprints: Requests for reprints must be addressed to authors.

Subscriptions and Journal Exchanges: Address all correspondence to the CHAIRMAN OF THE EDITORIAL BOARD.

Advertising, News Releases: Advertisements and news releases will not be published in the Journal.

ISSN 002-4112

CONTENTS

SYMPOSIUM: ENERGY AND ALABAMA

Solar Energy: Can We Use It Now? J. S. Goodling	62
The Role of Coal in Our Energy Future Irving Wender	68
Nuclear Fission: Risk vs Need Raymond F. Askew	79
Biomass Energy Sources for Alabama Klaus Steinbeck	86
Energy: Need Versus Demand Edward Passerini	92
Energy and Economics Donald R. Street	97
Effect of Topsoiling on Alabama-Area-Bituminous- Coal-Mining Production Cost J. Earl Bailey and Walter Misiolek	105

ARTICLES

The Physiochemical Limnology of a Temporary Pond in North Alabama Richard F. Modlin	119
Information Needs and Sources of Alabama Farmers James L. Stallings and George L. Harrison	131
Rural Real Estate Markets in Major Agricultural Areas of Alabama John L. Adrian, Jr.	152

1980 ANNUAL MEETING
SPECIAL SYMPOSIUM

ENERGY AND ALABAMA

Moderator: Chester C. Carroll¹

America's need for a concentrated commitment to a program of research and extension to insure the continuing availability of adequate energy supplies is a source of immense concern for all elements of our society. So far, the energy crunch has stimulated little more constructive effort than a few fragmented attempts to resolve fairly small scale problems. While citizens are increasingly aware of the escalating expenses involved with the utilization of all forms of energy, there has been a general lack at both the national and state levels of any coordinated and comprehensive plans for dealing with this critically important matter. The time has come to meet this issue face-to-face. We must have a comprehensive energy plan, including programs of research and extension to assist our people in securing adequate supplies of needed energy.

It is of utmost importance that institutions of higher learning play a major role in these activities through accelerated research and extension programs. The state universities of Alabama are a major focal point at which we find not only the necessary research tools and capabilities but also the diversity of intellectual resources needed to address the complex energy problems. Research will play the principal role in guiding the continuing development of energy resources, for investigating alternatives for energy conservation, and for developing energy-efficient processes and devices. This effort must proceed along a broad front, for it must consider equally the needs of our industries, businesses, farms, and homes. Extension will play an increasingly essential role in conveying the results of this research to the consumers.

Alabama has both the natural and intellectual resources to significantly contribute to this important area of human concern. It is now time for our state to assume that role. This symposium hopefully will highlight some obvious needs for overall planning and coordination.

¹Dr. Carroll is Vice-President for Research at Auburn University. Trained as an electrical engineer, his extensive experience includes teaching, research, departmental headship, and consultant for the National Academy of Sciences.

SOLAR ENERGY: CAN WE USE IT NOW?¹

J. S. Goodling²

Department of Mechanical Engineering
Auburn University
Auburn, AL 36830

Man, in the generic sense, is a puny being, unendowed with great physical strength. Our history is filled with accounts of successful attempts to overcome this innate weakness by using things found in nature that are more powerful than we are. It began when we first climbed upon a horse, has progressed through devising a machine on wheels with the power of 400 horses and has reached the point of producing that equaling the power of 10 million horses in the volume of a few cubic meters--a nuclear reactor.

One result of the industrial revolution has been the availability of a multitude of power multiplying devices, each fueled by a petroleum source--traditionally gas, coal, or oil. This nation of over 200 million people uses up an astronomical amount of energy per year--80,000 trillions of BTUs--or about 4 billion horses working full strength, full time. All of this energy was ultimately derived from the sun.

In a discussion of solar energy utilization, it is first necessary to see how our energy is used now to fuel the myriad of power devices. The area of the figure below represents total energy consumed in the U.S. in 1979 and the wedges, the portion used by the various end-uses. Note that transportation and industrial heat (process steam and direct heat) account for one-half of the total. Both of these segments require fairly *high temperature* energy. Another quarter uses, almost of necessity, electricity. The remaining categories (space heating and water heating) make up the last quarter. Both are low temperature applications. Each quadrant requires about 1 billion horses working full time, full strength.

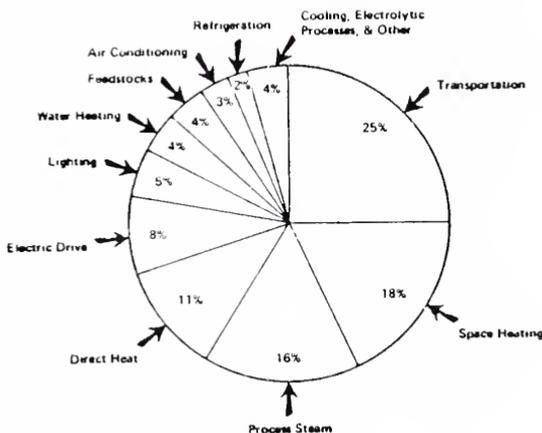
Can solar energy provide all this energy now? Is it possible? Yes!
Will solar energy provide all this energy in the future? Probably not!

¹An invited paper presented at the 1980 Annual Meeting of the Alabama Academy of Science Symposium on Energy and Alabama at Samford University, Birmingham, Alabama, March 22, 1980.

²Dr. Goodling is an Associate Professor in the Department of Mechanical Engineering at Auburn University, and is involved in both teaching and research. His research interests include heat transfer, thermodynamics, and energy utilization. The students in the School of Engineering named him Outstanding Engineering Faculty Member in 1975.

GROSS ENERGY USE: 80×10^{15} BTU

4×10^9 HP-YR



To see why not, it is necessary to understand something about the quality and quantity of solar energy on earth. It goes without saying that the sun usually rises and sets daily--except perhaps in Las Vegas. This predictable regularity is not new. Occasionally the clouds get in the way, but in a not-so-predictable nor regular fashion, at least for short periods of time. In April, Washington, D.C., on a clear day, at noon, the quantity of energy falling on a horizontal surface is about 600 watts/m² or about 0.8 hp per 10 ft². In the winter this value is decreased about 20% and in the summer, it is increased a like amount. But the intensity of radiation is less than this value for hours other than high noon. Averaging over the daylight hours reduces it to 1/3 that value and over the day, to 1/6. The result is that about 1/10 of a horsepower falls on 10 ft² on the average--an easy number to remember.

This solar energy can be used to quench our energy thirst in numerous ways. Two broad categories of utilization are microscopic and macroscopic.

By microscopic, I mean that the solar radiation, considered as oscillating electric and magnetic fields (waves), interacts with matter at the atomic or electronic levels. One such process is the synthesis of organic molecules with higher energy than their inanimate components (CO₂ and H₂O). This higher energy is derived from small quantities of radiation called photons and the process is called photosynthesis. Since carbon dioxide and water vapor are nearly transparent to solar energy, a light absorbing molecule is required for the process. Its name is chlorophyll. The process is complex and not thoroughly understood, but essentially the chlorophyll atom absorbs solar energy, becomes energized and aids in the synthesis of strings of carbon, hydrogen

Solar Energy

and oxygen atoms--called carbohydrates. This biomass can be converted directly to thermal energy or converted to alcohols for consumption by humans or internal combustion engines like ethanol or methanol. The conversion of carbohydrates to liquid hydrocarbons is an energy intensive process and whether we increase our net storehouse of energy is a debatable question. A major benefit of intentional biomass conversion of solar energy is the time integration of the variable solar intensity over a period of months. Since only a small portion of the solar energy is required for photosynthesis, the efficiency is low--around 3-10% for most crops.

Coal, gas and oil are the products of this time integrated photosynthesis, but the period has been millions of years, not months. In view of our rapidly diminishing known petroleum supplies, it is interesting to observe that our species will use up in a few hundreds of years what natural processes took millions of years to produce.

Photovoltaics is the name of a man-devised process whereby photons (small quantities of light energy) impart their energy to electrons in solid materials, sufficient to cause them to overcome orbital bonds and to become free to flow through the material and provide electrical current. The efficiency of this conversion process is about 10%.

The second category of solar energy conversion can be called large-scale or macroscopic. By this I mean hydroelectric, ocean thermal, wind and direct solar thermal. The first three make use of differences created by solar energy. For hydroelectric, heating of surface water enhances evaporation. These vapors rise, later condense and are deposited at higher elevations. The difference in water level can be easily converted to work energy. As is the case of the Gulf Stream, the heated waters at the surface are at temperatures sufficiently higher than those of the bottom waters to allow for a heat engine to operate between them and generate work. Wind energy can also be converted to drive rotating blades and generate work.

Most solid materials absorb and convert solar light waves into thermal energy, resulting in an increase of temperature: black asphalt road tops and human skin being good examples. As long as the solar energy impinges on a solid surface the temperature rises until a point of equilibrium is reached, whereby the solar energy coming in equals the energy lost to the local surroundings. The net temperature rise at equilibrium is usually *tens* of degrees above the ambient temperature. This leads to the use of low temperature applications of solar energy primarily for domestic hot water, space heating and air conditioning, all three of which are called direct solar.

Again, we must look at consumption of energy for these uses. The figure below shows the fractions of energy used in residential and commercial energy by end use.

Note that space heating is about 2/3 of the total for both sectors. Hot water heating is 10% for commercial and 15% for residential structures. Air conditioning constitutes only several per cent for both, but obviously this is a function of geographical region.

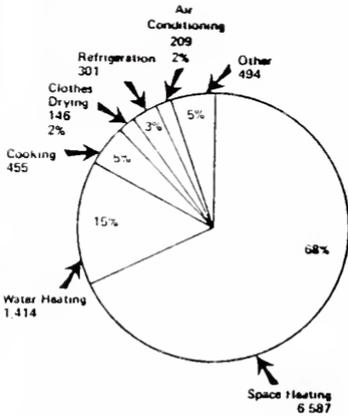
GROSS ENERGY USE:

$$10 \times 10^{15} \text{ BTU}$$

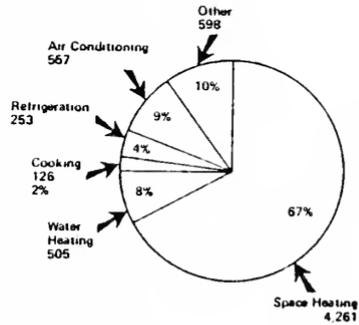
$$0.5 \times 10^9 \text{ HP-YR}$$

$$6.5 \times 10^{15} \text{ BTU}$$

$$0.3 \times 10^9 \text{ HP-YR}$$



Residential End Use



Commercial End Use

The magnitude of those energies can be approximated for a typical home in the Southeastern U.S., both in BTUs and horsepower.

	BTU	Horsepower-Year	A_c, ft^2
Space Heating	42×10^6	1.9	475
Air Conditioning	35×10^6	1.6	400
Hot Water	15×10^6	0.7	175
Cooking	5×10^6	0.2	-
Electric Appliances	2×10^6	0.1	-
Lighting	1×10^6	0.1	-
	100×10^6	4.6	

Space heating, air-conditioning and domestic hot water can be fueled by direct solar energy, but obviously, not cooking, electrical appliances or lighting at night. How is this done? Presently, solar collectors mounted outside a building envelope are used to absorb the energy and transfer it to a fluid, which is transported to the interior of the building for use or storage. Storage of the collected energy is necessary as the time integrator of solar energy since its availability is usually out of time-phase with demand for that energy. Air conditioning systems are the opposite; i.e., the solar energy is available when the air conditioning is needed. But efficiencies of these devices range around 30%. That is, only 30% of the solar energy falling on the

Solar Energy

the collectors is delivered as useful low temperature energy for refrigerating spaces.

From the previous discussion, we found that about 1/10 hp of solar energy falls on 10 ft². This fact allows for a determination of how much collector area is required for the various energy end uses. The areas required are for 100% of the energy needed.

For space heating and air conditioning, the areas are about the size of half a roof on a modest home. Thus a solar collector array is conveniently mounted on the southern exposed roof of a dwelling. The collectors, storage containers, piping, controls and other equipment necessary for using solar energy are made of glass, copper, steel, insulation--all energy expensive materials. The systems are designed (sometimes) by engineers and installed by plumbers, carpenters and electricians. The total cost is about \$20 to \$30 per ft² of collector. Obviously a great deal of capital outlay is required to make use of this "free" solar energy. Even when the interest rates, tax savings and fuel savings are discounted back to present worth, the systems rarely make money for the owner/user. However, the solar energy used in low temperature applications such as these displaces our finite petroleum fuels. These compact, time-integrated and stored fuels should be reserved for high temperature applications such as power plant boilers or locomotion.

There are still some major non-technical problems associated with solar, a few of which I will mention.

(1) The rather substantial tax credits made available by the Federal government are meant to encourage the fledgling solar industry. I don't believe that the government should continue indefinitely to support an industry that cannot support itself in our capitalistic system.

(2) Various organizations are attempting to write codes and standards to regulate system sizing, to guarantee component performance, to prevent fire hazards, pressure vessel explosions, structural failure, sun rights and other things necessary to protect the public from bad engineering and charlatans. However, some agency must enforce such codes.

(3) Prices of solar systems were projected to decrease as production and installation became commonplace. The opposite has been true. Prices of installed systems have increased at inflationary levels or more.

Are we using solar energy now? Yes, domestic hot water heating systems of good quality can be purchased and installed. But they are expensive and the money saved is not large. Space heating systems are being marketed in the northern and western U.S. but they are more expensive than hot water systems and not commonplace yet. Biomass has the advantage of natural long term storage and the disadvantage of low efficiency. Both the net energetics and economics appear border line. Photovoltaic conversion has the potential for wide-spread use since the photocells could be produced in quantity.

When asked recently what is the best direct solar energy investment today, Dennis Hayes, Director of the Solar Energy Research Institute, replied, "Passive Solar Design." I have not mentioned that aspect of solar because it is clearly within the perview of the architect which I am not.

REFERENCES

- (1) Phillip Steadham, *Energy, Environment and Building*, Cambridge University Press, 1976.
- (2) J. T. Krenz, *Energy Conversion and Utilization*, Allyn and Bacon, 1976.
- (3) *Energy Facts II*, Committee on Science and Technology, U.S. House of Representatives, August 1975.

THE ROLE OF COAL IN OUR ENERGY FUTURE¹

Irving Wender²

*U.S. Department of Energy
Office of Fossil Energy
Washington, D.C. 20545*

INTRODUCTION

It is difficult to predict, with any real degree of accuracy, the role of coal in our energy future. Several studies have attempted to forecast the role of the many energy resources available to the United States. In essentially every case, each study has found it necessary to propose two or three scenarios forecasting different levels of annual U.S. energy production. The scenario that results from a sudden and almost complete cut-off of OPEC and other foreign oil supplies is frightening but somewhat hazy; we hear of gas rationing, of sending part of our own production to Europe and to Japan, of greatly increased use of coal and nuclear power, of draft registration and even of war.

We are an energy rich country; our coal reserves far exceed our petroleum reserves and even exceed, in terms of Btu's, the entire resources of the Middle East. Proven U.S. coal reserves could probably last over 500 years at present consumption rates. But obstacles to mining it and to burning it in a socially acceptable manner, among other reasons, have limited its use, and new technologies to convert coal to electricity and synthetic fuels need perfecting. There is no doubt that more of our coal will be used in the future but just how much and what proportion of our energy will be derived from coal are not clearly defined.

THE NATIONAL NEED

What is our situation today? In the National Energy Plan (NEP) presented to the nation in 1977, President Carter said, "We can protect ourselves . . . by making the most of our abundant resources such as coal . . ." On April 5, 1979, nearly two years later, the President

¹An invited paper presented at the 1980 Annual Meeting of the Alabama Academy of Science Symposium on Energy and Alabama at Samford University, Birmingham, Alabama, March 22, 1980.

²Dr. Wender is Director of the Office of Advanced Research and Technology in the office of the Assistant Secretary of Fossil Energy. Trained in organic chemistry, he has been involved for several years in fossil fuel research.

emphasized the extreme importance of coal for short-term needs. He stated that during the transition to full-scale development of alternative technologies, coal "would be our most important source of fuel."

But today's situation doesn't quite bear out that picture. Despite our national policy to increase its use, coal is demand-limited. Coal accounts for about 18 percent of domestic energy use today, the same level as over the past few years. But production capacity exceeds demand by over 100 million tons per year.

Before we look at some of the reasons for this situation, let us look at how much coal is now produced and how it is used. Table 1 shows coal consumption, including exports, production, and imports from 1977 to 1979, and the National Coal Association (NCA) Economics Committee estimates for 1980.¹

The 766 million tons forecast for 1980 would be a record for the coal industry. The increased production would come from Western mines and would be used mainly to supply new electric power plants in the west and southwest. Slightly increased use by utilities and industries in the east will probably be offset by a million ton decline in the use of coking coal.

TABLE 1
CONSUMPTION AND PRODUCTION OF COAL IN THE U.S.,
1977-1980 (Millions of Tons)

	1977 ¹	1978 ¹	1979 ¹	1980 ²	% Change 1980/79
<u>Consumption</u>					
Electrical utilities	475.7	479.1	529	555	+ 4.9
Coking coal	77.4	71.1	76	75	- 1.3
General industry and retail	67.4	67.7	67	73	+ 9.0
Total domestic	620.5	617.9	672	703	+ 4.6
<u>Exports</u>					
Canada	17.2	15.2	18	18	--
Overseas	36.5	24.6	41	44	+ 7.3
Total consumption	674.2	657.7	731	765	+ 4.7
<u>Production</u>					
East	527.4	469.0	540	540	--
West	163.9	184.8	216	236	+ 9.3
Total	691.3	653.8	756	776	+ 2.6
<u>Imports</u>					
Steam coal	1.8	3.0	2	2	--
Coke	1.8	5.3	4	3	-25.0

¹US Department of Energy

²NCA Economics Committee estimates

The Use of Coal in Our Energy Future

The NCA survey also predicts that the nation's electric utilities are increasing their long-term commitment to using coal. The NCA found that 243 coal-fired units are now scheduled to begin operation in 1988, the total planned for the next ten years rises to 271. Table 2 shows the division in new utility generating units among coal, nuclear, oil, and other fuels; coal leads with 51.3 percent of total new planned capacity.

TABLE 2
NEW UTILITY GENERATING UNITS PLANNED TO
BEGIN OPERATIONS, 1979-1988

Fuel	No. of Units	Capacity (Mw)	Percentage of Total New Capacity Planned
Coal	271	142,107	51.3%
Nuclear	93	102,431	37.0%
Oil	9	5,502	2.0%
Other	329	27,026	9.7%
Total	702	277,066	100.0%

Under "Other" in Table 2, the planned units include hydroelectric, combustion turbines, internal combustion, combined cycle, and geothermal.

Nearly half of the new coal-fired capacity will be built in regions of the country now predominantly dependent on oil and natural gas for the generation of electricity. More than half of the new coal capacity will be built west of the Mississippi and the majority of those new units will be added in the Gulf and "Sunbelt" states.

Since last year, utilities have reported significant delays in the scheduled dates of operation of new power plants. Fifty-seven percent of new coal-fired capacity reported delays, while 71 percent of planned nuclear power plants were delayed. Specific reasons for delays vary, but the National Electric Reliability Council reports that the most common reasons are revisions in forecast demand for electricity, delays in siting or licensing, problems with preparation of environmental data or financial uncertainties.

If all coal-fired units are brought into service as planned and utility growth proceeds as expected, the share of electric power generated from coal should rise from 46.4 percent in 1977 to 49.2 percent by 1988. In 1979, coal use by utilities reached a record 529 million tons. If all new coal capacity planned is brought into service, utilities could use as much as 880 million tons in 1988.

In a provisional estimate by the Department of Energy (DOE) (since revised), demand for coal could increase at an average annual rate of 5.1 percent through the year 2000, from 664 million tons per year in 1978 to 1.4 billion tons in 1990 and 2.0 billion tons by 2000; the average annual growth in demand between 1970 and 1980 was 2.7 percent. The demand for coal by sector is projected in Table 3.

TABLE 3
COAL FORECASTS BY YEAR: MILLION TONS OF COAL EQUIVALENT
(1 ton = 22.5 million Btu)

	1978	1985	1990	1995	2000	1978-2000 Avg Annual % Change
Industrial	142	240	300	360	390	4.7
Utilities	481	680	990	1100	1170	4.1
Synfuels	0	~3	40	130	330	
Export	41	80	90	100	110	4.6
Total	664	1003	1420	1690	2000	5.1

However, if additional environmental constraints are placed on coal supplies and use, an alternative set of planning assumptions would show growth in coal demand of only 3.7 percent per year. This would reduce the ability of industry and utilities to use coal and could result in slower development of synthetic fuels. With this slower rate in coal demand, 1,120 million tons of coal would be produced in 1990 and 1,460 million tons by the year 2000 (Table 4).

TABLE 4
COAL FORECASTS BY YEAR: MILLION TONS OF COAL EQUIVALENT
(1 ton = 22.5 million Btu)

	1978	1985	1990	1995	2000	1978-2000 Avg Annual % Change
Industrial	142	210	250	280	290	3.3
Utilities	481	640	760	770	830	2.5
Synthetics	0	0	30	89	230	
Exports	41	80	80	100	110	4.6
Total	664	930	1120	1239	1460	3.7

The Use of Coal in Our Energy Future

Coal demand is expected to increase more rapidly due to an improved competitive position relative to other fuels. Between 1976 and 1978, the average nominal cost of coal delivered to utilities increased 32 percent compared to an oil price increase of 9 percent, but future coal prices are expected to grow more slowly than oil prices. Coal prices are expected to increase at slightly more than 0.5 percent per year real between 1980 and 1995, and oil prices at slightly less than 3 percent per annum (but oil prices may go out of sight in the not too distant future). Coal prices are likely to track coal production costs, which are expected to increase less rapidly than oil prices. There is another point of view--coal prices may increase more rapidly, perhaps at a rate approximating oil price growth. Future coal production is expected to increase to about a billion tons in 1985 and to keep pace thereafter.

In the near term, increases in coal production and use must depend upon greater conventional use of coal in the utility and industrial sectors. In the long term, additional increases in the use of coal will depend upon new, non-conventional coal technologies and adequate coal production.

A number of government agencies are involved in coal production. The Department of Interior is responsible for coal leasing and for regulating the way in which coal lands are reclaimed. The Department of Labor regulates the safety aspects of how coal is mined. The Department of Energy can develop new mining techniques to reduce costs and facilitate the ability of the coal industry to meet environmental requirements and overcome institutional barriers. The government must take a strategic approach to the mining research, development and demonstration program taking into account the resource base, the need for increased productivity, the type and physical characteristics of the various coal seams, the size of the mining company and environmental considerations.

A special aspect is that the environmental constraints on Western coal production have increased significantly during the past few years and may continue to increase in the future. As a result, more Eastern coal than presently forecast may be needed. Efforts should be made to minimize environmental degradation due to coal production in the West, while increasing viable technological options in the East.

NEAR-TERM COAL USE

The Powerplant and Industrial Fuel Use Act (FUA) will be used to require use of coal (or other alternative fuel) in all new electric utility power plants and major industrial fuel burning installations (units with a heat input of 100 million Btu's per hour or more) and in existing coal-capable facilities.

Although legislation has been in effect since 1974 requiring conversion of utility and industrial boilers to coal, very little has actually been accomplished. Numerous loopholes and lengthy litigation have tied up the program. A major problem has been bringing coal-fired boilers into compliance with air pollution regulations.

An Administration announcement, early in 1980, of an ambitious program requiring power companies to switch from burning oil to domestic coal has set the stage for a major environmental battle. The goal of this program is to replace the equivalent of one million barrels of oil per day and natural gas by 1990. Initially, the plan involves the mandatory conversion of 107 power plants, most of them in the Northeastern and Mid-Atlantic states. Forty million extra tons a year of Eastern coal would be required. Revenues collected by the windfall profits tax on oil companies is expected to provide \$3.6 billion to help utilities pay for mandatory conversion through Federal grant assistance. The first stage would involve only power plants now capable of converting to coal. The second stage would involve an additional \$6 billion in assistance to utilities mostly located in the Southeast, Southwest and California. These plants need considerable aid to help them switch to coal.

Recent price increases in oil have improved the prospects for coal use in large new utility and industrial boilers. Price will probably drive the industrialization effort in direct coal combustion; the relative economics of coal versus oil and gas for large new boilers will probably discourage the use of oil or gas where coal is physically and environmentally feasible.

COAL FOR COKE

A word about coal for making coke is in order. Next to the generation of electricity, the next largest use of coal is to manufacture coke for the steel industry. Unfortunately, not much attention has been paid to America's declining coke making capacity, incredible as that may seem for a nation with the largest reserves of good metallurgical coal in the world. Steelmaking depends on the use of coke but U.S. steelmakers do not have enough coking capacity to supply their needs and could not operate long at full capacity on domestic coke alone. In 1978, the country fell short about 8 million tons, most of which was supplied by West Germany, a country that subsidizes each ton of coal mined. (In 1978, bituminous coal in West Germany cost about 120DM per ton (about \$60 per ton) of which 50DM is government subsidy.)

And the coke shortage will get worse. The shortfall may grow to between 10 and 12 million tons by 1985 as more coke batteries are forced to close and not enough new ones open. The coke shortage now costs the coal industry about 8 million tons of annual coal production with 6000 lost jobs in the mines and 3400 lost jobs in coke plants.

Admittedly, coke making is a dirty business. Equipment is available to capture emissions but it is expensive, and may create hazardous working conditions. Many American plants are too old to be worth cleaning up. The average coke plant is next door to a steel mill, usually in a highly industrialized area. This creates a problem with the Environmental Protection Agency (EPA) which is concerned with construction in heavy-industry zones. In other words, it is not easy to get a permit to build a coke plant.

The Use of Coal in Our Energy Future

The life expectancy of a coke plant is 25 years. Unfortunately, 35 percent of our coke plants are more than 25 years old and another 20 percent are in the 20 to 25 year category. Between December 1975 and the middle of 1979, 32 coke oven batteries (14.7 percent of maximum annual capacity) were permanently taken out of service. The combination of regulations coupled with the aging of existing batteries will further reduce the nation's coke output. And, to make matters worse, a million ton battery that cost \$85 million in 1969 costs about \$186 million in 1978.

Perhaps a collection of diversified companies having ties with the steel industry could finance, build and run large central coke plants with good economics of scale and acceptable environmental safeguards. The know-how is here although it could be improved. Both new research and now influxes of capital are needed. We should return, as rapidly as possible, to the days when exports of coal and coke were a major contribution to our balance of trade.

EXPORTS OF COAL--A COMING BONANZA?

At a recent meeting of the International Institute for Applied Systems Analysis (IIASA), one of the delegates made a surprising but, in a way, not totally unexpected prediction. He thought that Europe might need as much as one billion tons of coal from the U.S. by the year 2000. Indeed, many foreign countries would like to obtain coal from the U.S. and delegations from France, West Germany, Japan, Spain and Denmark have visited this country during the last few months. But concern has been expressed about the unreliability of supplies due to sudden domestic political moves and about the lack of infrastructure for exports. To produce a really significant impact on world energy would require the existence of better rail transport, enlarged port facilities and more and bigger coal-carrying ships. Nevertheless, there is little doubt that exports of steam and metallurgical coal from the U.S. will increase greatly in the near future, perhaps by as much as 100 million tons by 1985 and more later. The future of coal is therefore bright, even though coal operators are not doing well now.

This foreign interest, if translated into sales, would put many coal miners back to work, reduce the nation's balance of trade deficit and help wean allies from dependence on foreign oil. We must learn how to supply this coal for export without undue environmental damage to our land.

SYNTHETIC FUELS

At the moment, this country desperately needs new sources of transportation fuels. The two most promising sources are coal and oil shale. There are two principal ways of obtaining liquid fuels from coal: by the direct hydrogenation of coal and by the indirect liquefaction route. The latter involves the gasification of coal to synthesis gas (carbon monoxide and hydrogen) and then the catalytic conversion of the synthesis gas to liquid fuels. Although the indirect route, as practiced by SASOL in South Africa or by the Mobil process (conversion of synthesis gas to

methyl alcohol which is then converted to high octane gasoline) can be implemented sooner than the direct hydrogenation path, the latter may be cheaper in the long run. We can expect to produce significant amounts of transportation fuels by the indirect route within the next 5 or 6 years, by the direct route after about 1990.

In February, 1980, Exxon dedicated a 250 ton per day pilot plant in Texas for the conversion of coal to liquid fuels by direct hydrogenation using their EDS process. Gulf, with Japan and Germany each contributing at least \$125 million, is designing an SRC-II coal hydrogenation demonstration plant to be built in West Virginia. A 6 ton per day plant at Wilsonville, Alabama, produces solid SRC-I; a hydrotreater is being added to this unit so that liquids can also be produced, if desired. And Ashland Oil is building a 250-600 ton per day plant in Kentucky. All these direct hydrogenation plants have government funding, as low as 50 percent for the EDS plant and larger amounts for the other plants.

It is important to realize that the gasification of coal is vital to both ways of converting coal to liquids. For direct liquefaction, about one-third of the capital cost is due to the manufacture of hydrogen made by gasification of coal or by gasification of the carbonaceous residue from the liquefaction process. In the indirect route, about 75 to 80 percent of the cost of the plant is taken up by the gasification of coal to synthesis gas. Although several new, "second generation" gasifiers are coming on stream, they have yet to be proven reliable and efficient. The Lurgi gasifier, used in South Africa, operates only on Western coal and makes significant amounts of methane. The Koppers-Totzek gasifier, which can gasify eastern coals, operates at atmospheric pressure; work is under way on a similar gasifier that operates at elevated pressures (the Shell-Koppers gasifier). The Texaco gasifier, suitable for eastern coals and for liquefaction residues, appears promising and several units are being built.

In the future, it is quite likely that most of our petro-chemicals will be made by gasifying coal to produce synthesis gas. The synthesis gas can be a source of high Btu gas, hydrogen, methyl alcohol, ethyl alcohol, acetic acid, ethylene and propylene and BTX (benzene, toluene and xylene) (see Figure 1).

In spite of great expectations for the coal industry, it is plagued with many problems. Safety in mines is a great concern, as are air pollution and acid rain, the problems associated with using flue gas scrubbers, the poor condition of the railroads used to transport coal, the heavy dependence of coal producers and users on railroads so that most coal moved by rail is "captive," troubles with the government's coal management program, boom towns, the possibility of management-labor unrest, etc. I know most of these are familiar to you. The coal industry has made great progress in grappling with these problems, but they are, in most cases, still with us and will require flexibility, research and development, improved human interaction and, I am afraid, a lot of patience.

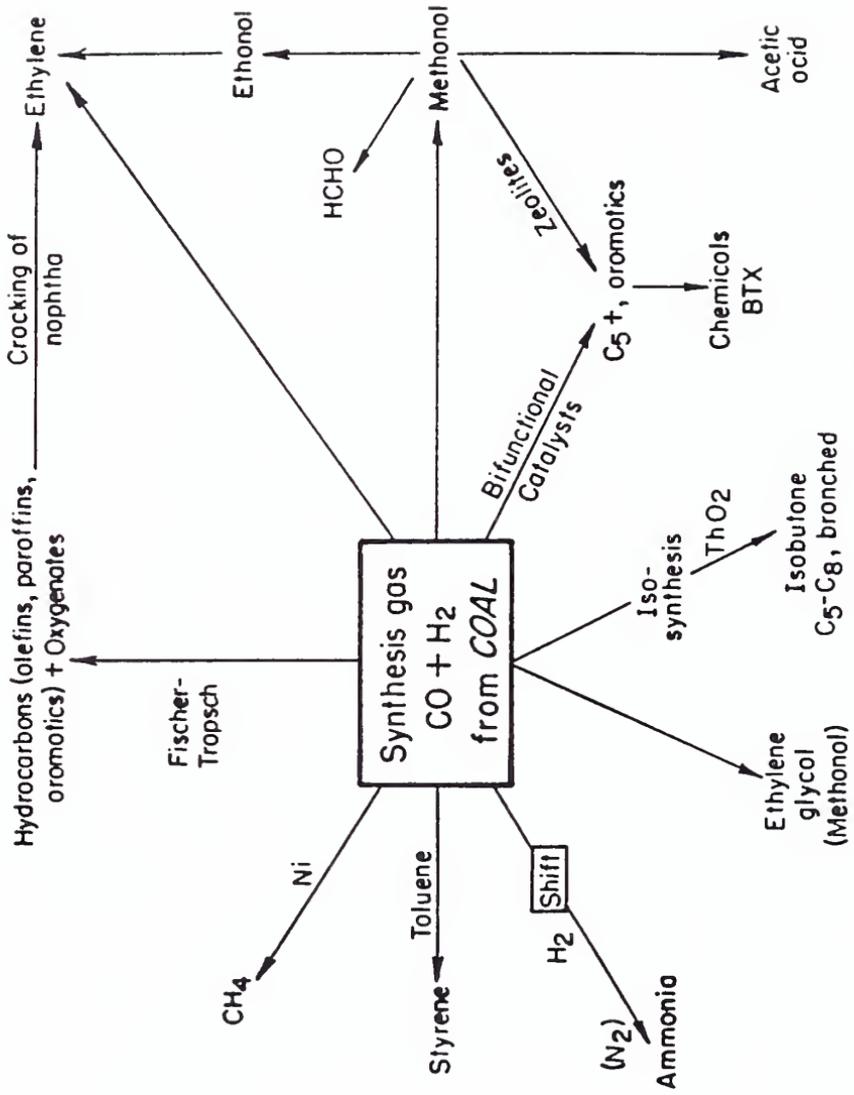


Figure 1. Some chemicals from synthesis gas.

Back in 1965, the beginning engineering cost of a coal-fired plant was about \$425/kw--that is in 1978 dollars--and pollution controls were responsible for about 10 percent of this cost. By 1978, the total was typically \$950/kw and environmental controls had reached about 40 percent. For 1985, the way things are going--and still in 1978 dollars--the cost of controls could represent 66 percent of the total coal-fired plant cost of \$1,600/kw.¹ That 66 percent is \$1,050, well above the whole plant cost in 1978. But research on scrubbers NO_x control, toxic waste handling and so forth could cut pollution control investment by 25 to 30 percent.

"There ain't no easy Btu's." I daresay all energy related activities damage or threaten to damage human health, the natural environment or the earth's biologic and geophysical system. Some of these activities involve environmental effects that are of such potential magnitude and are so hard to control that they may ultimately constrain the use of some energy sources; the adverse climatic effect of carbon dioxide (not at all proved) from fossil fuel burning is such an example. Another category includes potentially serious effects that are technically controllable but are now being so badly managed that both energy and environmental values may suffer unnecessarily in the long run; air pollution from fuel burning is probably the most important example in this case.

Other environmental problems associated with coal are no doubt relatively easy to solve technologically; they will probably be solved, with difficulty, within existing laws and policies. Reclamation of mined land, for instance, is usually not difficult or costly compared to the value of the resource extracted. Problems associated with boom towns or the passage of coal trains affect relatively few people and can be handled fairly easily. Even problems involving water use and water pollution need not be unsurmountable obstacles although they may thwart some particular projects. Although problems such as these are not trivial, they can be solved by persistent effort and negotiation on a case-by-case basis, together with careful and flexible management. But this will not happen quickly and much needed coal remains in the ground while miners remain at home--and our oil imports soar.

I would like to end on what I think is a timely note, although the following was written in 1856 by an Englishman named John R. Liefchild in a book entitled "Our Coal and Our Coal-Pits." In his opening paragraph, somehow remarkable today in view of the new gold rush and the prospects for coal, he said the following:

There are two words, each containing only four letters, but expressive of the two most valuable minerals in the world--COAL and GOLD. No two minerals are more valuable, none more opposite in outward appearance. The one is bright and dazzling, the other every man's comfort. The one is stored up in banks and bank-cellers, the other in coal-fields and coal-mines.

¹EPRI Journal, December 29, 1979, p. 73.

The Use of Coal in Our Energy Future

The one soils the mind of him who hugs it as a miser, the other soils only the face and fingers of him who gets it as a miner. The one is the apparent representative of the country's wealth, the other its real representative. . . . If gold and silver were no longer obtained for our use, society would, after certain evaluations and adjustments in adopting other representatives of value, go on as before. On the other hand, let civilized communities be deprived of their coal, and it is difficult to see how they could hold together as before.

NUCLEAR FISSION: RISK VS NEED¹

Raymond F. Askew²
Department of Physics
Auburn University
Auburn, AL 36830

What is nuclear fission and why does it create such controversy among proponents and opponents alike? This question must be answered before any attempt can be made to address the question of risk vs need for nuclear fission in our society. Fission, as it is generally called, is the process in which an atomic nucleus is fractured into "pieces," either spontaneously or with external assistance. Following this fracturing the "pieces" move apart from one another, with the smallest pieces (neutrons) moving at very high speeds while the larger fragments move at moderately low speeds. These larger pieces are atomic nuclei, each having significantly less mass than the original nucleus. They are also different in that each has different chemical properties from the original nucleus.

These tiny moving particles have energy of motion (kinetic energy) which is greater than the motion energy of the original nucleus. Most of this energy of motion is with the neutrons. Thus the fission of an element results in the liberation of kinetic energy to the resultant parts. It is this liberated energy that interests society, much in the same manner and for the same reasons that the burning of fuel oil and the associated liberation of energy interests us. Civilization perceives that energy availability is essential, although the quantity needed is widely disputed.

How much energy does fission provide? For each nucleus it is not much. The energy yield depends on what nucleus is fissioned. The one most commonly considered is an isotope of uranium, known as U-235. This nucleus would provide an average energy yield sufficient to warm about

¹An invited paper presented at the 1980 Annual Meeting of the Alabama Academy of Science Symposium on Energy and Alabama at Samford University, Birmingham, Alabama, March 22, 1980.

²Dr. Askew is a Professor in the Department of Physics at Auburn University. His research activities have included nuclear physics, radiation simulation, and plasma physics. He has been associated with projects involving isotope separation and fusion reactions. His current research activities include energy resources and utilization, heat cycle efficiencies, low density plasmas, and nuclear power systems.

Nuclear Fission: Risk vs Need

5-10 micrograms of water one degree celcius. This does appear miniscule, however it should be noted that the energy liberated in the burning of one octane molecule (a near facsimile of gasoline) is sufficient to heat only about 2×10^{-6} micrograms of water the same one degree celcius. Thus the ratio of energy yield per fission to that per octane molecule burned is approximately 10^6 .

Fission as a process was first discovered in the late 1930's. Although it occurs spontaneously, it is a relatively rare event. However, it was soon discovered that the process could be enhanced in U-235 if the nucleus were penetrated by a very slowly moving neutron. In fact, the enhancement was so favorable that it was possible to produce a relatively few fissions in a U-235 sample and use the neutrons liberated to cause more fissions in such a rapid time that the energy produced increased exponentially in only a fraction of a second. The attendant energy released would be equivalent to that of several thousand tons of TNT. Thus the "atomic bomb" was born.

The bomb and its use in World War II have produced a conscience of guilt on much of the United States community, and indeed on much of the world community. Fission, indeed all nuclear, is viewed as insidious to man due to its total invisibility and potential to cause health problems. To many it is impossible to separate the devastation and effects of the "bomb" from future risks of using the fission process in any manner. However the "bomb" can only occur when most of the neutrons produced are used to cause additional fissions. This requires that the U-235 atoms be closer together than is the case in uranium as it naturally exists. In fact, in naturally occurring uranium, only 0.7% of the contents are U-235 atoms. To produce a bomb the amount would have to exceed 7%. We can therefore utilize the fission of U-235 in a controlled manner (no bomb possibility) by using uranium at an enrichment of something less than 7%. We need only design a system which takes advantage of the neutrons liberated to the extent necessary to produce one new fission from each previous fission.

Why should we do this? What is the justification for developing and utilizing an energy production system based on the fission of U-235? The answer to this question is at first glance easy. The energy yield per unit of matter utilized is much, much more than just "significantly greater." Given that the uranium is available (and it is) it would appear to be a most reasonable source of energy. However, the matter is more complex for the answer involves one's personal biases. For example, there are those who argue that we must have growth in energy availability or society will stagnate, economic growth will stop, employment will be reduced, and in general the existing standard of living will be reduced. Others argue that we are an over-indulgent society and that by conservation we could reduce our need sufficiently to have adequate energy without fission playing a role.

The question of need simply cannot be answered by either of the above for neither addresses the real issue. Whether or not the United States and other developed nations adopt conservation will not forestall the need, indeed the demand of the emerging third world countries

for a proportionate share of the earth's resources. Oil, the primary energy source for most of the globe, is rapidly being depleted. In 1979 the global production of oil was approximately 23 billion barrels with a total reserve of about 642 billion barrels.¹ This provides somewhat less than a thirty year supply at current consumption rates. For certain there will be new oil discovered and previously non-economical oil reserves will be used when the price becomes economical. But the world does face the effective depletion of oil as a generally available commodity within the foreseeable future.

Oil,^{2,3} natural gas,⁴ and coal⁵ are very limited commodities, though coal resources should remain quite abundant, even with heavy use, for a few hundred years. More important than their short term value as energy resources are their long term values as renewable chemical compounds for products and goods within the world community. The most wasteful utilization of these materials is to burn them. Certainly oil and natural gas consumption as an energy source should be evaluated in light of their alternate long term values.

There are those who will perhaps disagree with the above attitude toward fossil fuels. Even so, continued use of fossil fuels at current growth rates or even reduced growth rates will likely produce an increase in the carbon dioxide content in the atmosphere. Accurate data on carbon dioxide concentration have been taken at the Mauna Loa Observatory, Hawaii since 1958.⁶ There has been a steady increase each year with a direct correlation with the increased consumption of fossil fuels worldwide. Although the exact effects of increased carbon dioxide in the atmosphere are not agreed upon, all projections based on current rates of increase propose significant climatological changes.⁷ In addition to the carbon dioxide problem there has been reported a significant environmental problem due to acid rain. This is attributed to the burning of coal.⁸

The above provide a basis for need of alternate fuels. Conservation can produce a significant reduction in energy consumption in such areas as home heating and cooling and hot water production.⁹ Improved fuel efficiency in transportation and industry can go a long way to reduce energy needs. But these measures will be expensive, in energy consumption. Most of what is proposed in the conservation area requires materials and equipment, all of which are highly energy consumptive in their manufacture. The energy cost over the next decade to produce these energy saving products will increase significantly the total energy consumed at a growth rate in excess of current values. The above assumes we are to move with great haste to accomplish extensive conservation within the next two decades.

Dollar economy is not the main issue in the question of energy availability. Societies need energy resources, if not to grow and develop, then to exist in harmony. Dollar economy arguments offer no answers for such economics may shift at a whim. What is necessary is that energy, in significant amounts, be available now and in the future. Fossil fuels alone cannot meet that need and indeed should not be so used.

Nuclear Fission: Risk vs Need

The immediacy of a potential energy shortage for any country is ever present with dependence on foreign governments for energy supplies. Growth potential and economic strength cannot exist without self-sufficiency in energy.¹⁰

Thus we have an energy need by the above criteria. But where do we look? Alternative sources will solve the problem we are told: wind power, geothermal, tides. These can make contributions of a few percent, depending on specific geographic locations. But they cannot produce the loss to be sustained by rapid decline in fossil fuel use. Again we are told that solar, synthetic fuels, and fusion all are "just around the corner." But they are not yet technically proven. Much work is yet to be done on the question of synthetic fuels and alcohol for transportation. To date definitive answers on chemical processes, by-product disposal, net energy yield, materials corrosion, and others have not been found. Fusion has been thirty years in its development and at no point has the legitimate, competent scientific community been as certain about the result as in the early days. The current definite time schedules to successful fusion have been set in accordance with government plans, not in accordance with known science and technology. Even if the most optimistic view is taken, practical fusion as an energy resource in significant application is beyond the turn of the century.^{11,12}

The support for solar energy as a substitute is filled with technical breakthroughs yet to be achieved. Though much is being done and time schedules of five years¹³ are discussed in terms of efficient photovoltaic cells for commercial use, these again are hopes. Home heating by solar is possible now in many parts of the world. To do it requires materials, equipment, labor, time, and energy.

The need for alternative energy availability away from fossil fuel is now. Fission provides that capability with proven technical feasibility and over thirty years of experience. It is the one alternate fuel resource which we have available with technical capability and which integrates directly into our current system immediately. The fuel is available for expanded fission energy production.¹⁴ The technology exists for producing additional fuel for even broader expansion through use of the breeder reactor, though this is not essential to having fission power to beyond the turn of the century.

But what is the price for using the fission process? As stated earlier, dollar costs are an inappropriate basis. The price we must consider includes pollution, environmental effects, health effects on the population. The term risk assessment is often used in connection with fission generated power when evaluating the cost and effect on society. It is a term which implies a potential for devastation, a continuance of the public conscience of the effects wrought on Japan. Its use thus places far more stringent emphasis on fission safety than on any other activity known.

The risk questions can generally be divided into three separate issues:

1. What are we going to do with the radioactive wastes which are generated in the fission process? These are the atoms which are created in the fission process, commonly referred to as fission fragments.
2. What is the possibility of a total fission system failure with attendant release of massive quantities of radioactive wastes?
3. What are the risks of proliferation of nuclear weapons material if we expand fission power generation? Recall that U-235 is not only the fuel for a fission energy system but also a fuel for a nuclear weapon. Also a second high grade nuclear weapon material, plutonium-239, is produced in a fission plant within the closed fuel system.

Each of the above is very difficult to assess. With regard to waste disposal, based on current technology, one must think in terms of long term (thousands of years) removal from a populated environment. Much work has been done to establish a reasonable and safe manner in which to store these products. The primary method which has been experimentally studied for most of the past decade involves intermixing the waste within glass during the formation of glass ingots. The glass is a non-leaching medium within the range of temperatures and pressures which would normally exist with such encapsulation. Recent studies have revealed, however, that highly elevated temperatures and pressures, in contact with a brine solution, will result in leaching of the radioactive wastes.^{15,16}

The disposal of the glass ingots would be in a salt dome mine in a geologically stable locale with air flow control and constant monitoring to insure against leakage. Total nuclear wastes generated through the year 2000 from expanded use of fission energy sources would require an underground area not in excess of 3-4 square kilometers.¹⁶

An alternative storage concept would involve locating the glassified wastes above ground in a naturally convective shaft for dissipating the residual heat from the decay process of the waste.¹⁷

Both of the above are subject to natural catastrophe, but based on geological data and seismic information at hand the probability of such an occurrence has been computed to be negligible.¹⁸

The recent accident at Three Mile Island is the nearest the United States has come to a major fission system failure. Projections have been done based on hundreds of studies of possible problems which could occur at a nuclear facility. In each of these, different catastrophe conditions have been postulated. There have in general been two strong positions taken with regard to all studies. These studies, such as the one by Rasmussen,¹⁹ always projected a very, very low probability for total system failure with attendant radioactive releases. In every case others question the validity of the model used to study the problem.²⁰ This situation has and still does exist because there had been no major nuclear system failures prior to Three Mile Island. Projecting statistics on no previous experience is at least weak and any attack can be

made as sound as the arguments being attacked. Nonetheless, risk values, including biological effects to the environment and humans, has been calculated prior to Three Mile Island.²¹

The results from Three Mile Island are more encouraging than discouraging with regard to system integrity and containment. The Kemeny report²² carefully points out that the emergency equipment and back-up equipment performed exactly as prescribed. Major problems were in personnel performances, company management, and regulating agency policies. In addition, the containment was found to be ten times more effective than design and estimated performance. The risk of a core melt-down from loss of coolant has now been reestimated based on the results at Three Mile Island. The risk factor is now lower than before, primarily due to an event upon which to establish a minimum data base.

The risk associated with proliferation of nuclear materials is difficult to assess. This factor will vary depending upon whether we restrict the use of nuclear fuel to the United States or export the technology to other countries who themselves surreptitiously remove the material for weapons development. Current nuclear operations do not include reprocessing used fuel to recover the unused U-235 and the plutonium-239 which is generated. Fuel used in reactors is not of weapons grade without further processing. However, there should be more than 500,000 kilograms of plutonium in used fuel rods by 1985.²³ This material is itself highly fissionable and could be used to extend fission beyond the time when U-235 is no longer available. However, because of its extreme value as a weapons energy source, added precautions would be necessitated to insure its security.

In summary, fission as an energy source appears our quickest and most energy efficient path to reduced reliance on fossil fuels. There are risks involved and need for long term waste disposal. The technical assessment of the risks have not changed appreciably as a result of Three Mile Island. Waste disposal has been addressed extensively, and a technically sound solution is available. Its lack of implementation appears more political than due to technical weakness. Indeed, given the quantity of radioactive wastes currently in temporary storage, the risk of release into the biosphere due to natural or unnatural catastrophe is far greater at present than would be the case in a salt dome burial site. Security of weapons grade fuel is not currently a problem but would require added attention should reprocessing be undertaken.

Perhaps the most noteworthy point in all the current literature with regard to risk was made by Wildavsky²⁴ when he notes that the greatest risk to mankind and civilization in general will be to take no risk at all.

REFERENCES

1. "Facts About Oil," American Petroleum Institute, 1980.
2. Fowler, Andrew R., *Scientific American*, 238, 42 (1978).

3. Root, David H., and Lawrence J. Drew, *American Scientist*, 67, 648 (1979).
4. 1976 Minerals Handbook, Vol. 1, U.S. Department of the Interior, p. 847-888.
5. Griffith, Edward D., and Alan W. Clarke, *Scientific American*, 240, 38 (1979).
6. Baes, C. F., Jr., H. F. Goeller, J. S. Olson, and R. M. Rotty, *American Scientist*, 65, 310 (1977).
7. *Symposium on the Global Effects of Environmental Pollution*, Ed. S. Fred Singer; D. Reidel Publishing Co., Dordrecht-Holland, 1970.
8. Likens, Gene E., Richard F. Wright, James N. Galloway, and Thomas J. Butler, *Scientific American*, 241, 43 (1979).
9. Ross, Marc, *Physics Today*, 33, 24 (1980).
10. Starr, Chauncey, *EPRI Journal*, 1, 6 (1976).
11. Kulcinski, G. L., G. Kessler, J. Holdren, and W. Häfele, *American Scientist*, 67, 78 (1979).
12. Furth, Harold P., *Scientific American*, 241, 50 (1979).
13. Private Communication, R. D. Schmidt.
14. Deffeyes, Kenneth S., and Ian D. MacGregor, *Scientific American*, 242, 66 (1980).
15. Kerr, Richard A., *Science*, 204, 289 (1979).
16. Cohen, Bernard L., *Scientific American*, 236, 21 (1977).
17. Hammond, R. Phillip, *American Scientist*, 67, 146 (1979).
18. Kerr, Richard A., *Science*, 204, 603 (1979).
19. Rasmussen, Norman, *Reactor Safety Study (WASH-1400)*.
20. Lewis, Harold W., *Special Report on WASH-1400*, National Research Council, 1978.
21. Cohen, Bernard L., *Rev. Mod. Phys.*, 49, 1 (1977).
22. *Kemany Commission Report*, U.S. Government Printing Office, Document No. 052-003-00718-51, 1979.
23. Greenwood, T. H., H. Feiveson, and T. Taylor, *Nuclear Proliferation*, McGraw-Hill Book Co., New York, New York, 1977, p. 175-181.
24. Wildavsky, Aaron, *American Scientist*, 67, 32 (1979).

BIOMASS ENERGY SOURCES FOR ALABAMA¹

Klaus Steinbeck²
School of Forest Resources
University of Georgia
Athens, GA 30602

Biological raw materials have only recently regained broad recognition as energy sources in the United States, even though more than one billion people in the world today depend primarily on wood for their energy. But the potential of many biological materials ranging from animal and human wastes to agricultural crops and forest vegetation to marine and fresh water plants is under active scrutiny today, both in the U.S. and abroad. It is not feasible to assess the potentialities and research needs for all biological energy sources adequately in one paper. Therefore my charge has been narrowed to the identification of instances involving terrestrially grown plants which hold promise as alternate energy sources for Alabama. Even this narrowed focus will necessitate considerable personal judgement because hard data of availability, price, energy balances, conversion efficiencies and other aspects do not yet exist.

OVERVIEW OF TERRESTRIAL BIOMASS ENERGY SOURCES

Biomass already is a significant energy source for our nation. The Council on Environmental Quality in its report "The Good News about Energy" (Anon., 1979a) estimates that of the total 1977 U.S. energy consumption of 78 quadrillion British thermal units (quads), about 1.8 quads originated from biomass. Most of this was produced and used by forest based industries. The pulp and paper industry, for instance, is among the top 10 industrial energy users in the U.S. and probably is meeting half of its energy needs with biomass. But the potential of forest biomass is much larger than what is currently being realized. A task force of the Society of American Foresters investigated forest biomass as an energy source (Anon., 1979b), and reported that of an estimated total net annual growth of 530 million tons of forest biomass in the U.S.,

¹An invited paper presented at the 1980 Annual Meeting of the Alabama Academy of Science Symposium on Energy and Alabama at Samford University, Birmingham, Alabama, March 22, 1980.

²Dr. Steinbeck is an Associate Professor with the School of Forest Resources at the University of Georgia. Trained in Silviculture, his research involves the biology of short-rotation forests with emphasis on increasing yields to provide raw materials for fiber, food, energy, or chemical feedstock.

only 200 million tons are currently being used by forest industries. They further estimated that the equivalent of 9.5 quads is potentially available from commercial forest lands in the U.S. right now.

Agricultural products also are being used as energy sources. The current embargo on American grain shipments to the Soviet Union has accelerated federal programs to convert surplus grain into alcohol and other fuels. Policy considerations in terms of energy imports, agricultural exports, and maintenance of stability in the agricultural sector of the economy affect this type of biomass energy source perhaps more than any other. Major research efforts are under way, most notably in the U.S., Canada, and Brazil, to evaluate energy balances for crops. If the entire process from crop production to conversion requires as much energy as it finally yields, one type of fuel would simply be converted into another with no particular net energy benefit. Because of the range of assumptions which can be made concerning energy inputs and outputs, confusion currently reigns supreme in this area. In a preliminary report concerning the conversion of grain to ethanol, Hertzmark (1979, pg. 4) arrives at a range of energy inputs to outputs ratios from 0.39 to 1.7, on the whole not a very encouraging outcome.

Energy inputs required to collect agricultural residues are relatively small. Miller and Schooley (1979) estimate that "After deducting the energy requirements for preparation, collection, transportation, and increased fertilizer use, 8 to 13 million Btu per dry ton of energy is potentially available. These figures do not include conversion." Agricultural residues potentially available as alternate energy sources are predicted at 321 million dry tons for the entire U.S. in 1980 (ibid.).

Herbaceous vegetation also has potential for terrestrial energy farms and a species screening program is under way. For the southeastern states, 20 promising herbaceous species have been identified (Saterson et al., 1979). The four with the greatest reported productivities were Bermuda grass (*Cynodon dactylon*), kenaf (*Hibiscus cannabinus*), napiergrass (*Pennisetum purpureum*), and forage sorghum (*Sorghum bicolor*). One of the problems which this study encountered was that no reliable productivity data were available for some of our rankest weeds like giant ragweed (*Ambrosia trifida*), pigweed (*Amaranthus retroflexus*), and others more. Therefore a field testing program for herbaceous species will be initiated by the Department of Energy.

All these types of biomass--forest vegetation, agricultural crops, and herbaceous vegetation--share certain advantages and disadvantages as energy sources. Perhaps the most important positive, long-term aspects are that they are renewable indefinitely, cause no net change in atmospheric carbon dioxide levels and contain relatively few pollutants. Other advantages include that materials which previously were not marketable or constituted a disposal problem in manufacturing processes can be utilized. Site preparation for the next crop also often is facilitated by more complete use of the previous crop. Biomass is versatile in that it can be converted into a variety of liquid or gaseous fuels or directly into heat. Drawbacks of biomass include the removal of nutrients and organic matter from soils and its seasonal availability,

Biomass Energy Sources

especially pronounced for the annual plants. Harvesting and transport costs are high because the resource is generally scattered, bulky and high in moisture. Conversion plants or satellite pretreatment plants will therefore be relatively small.

BIOMASS ENERGY SOURCES IN ALABAMA

As assessment of biomass energy sources and a determination of their research needs logically begins with land availability. Alabama has a total land area of 33.1 million acres and 65% of this is classified as commercial forest land (Hedlund and Earles, 1973). Therefore this category probably contains the largest acreage potentially available for energy production in Alabama. Approximately 11.8 million acres are in farms (Anon., 1974); this figure includes cultivated land, pasture and range, and probably some forest land. The major agricultural areas are in the southeastern section of the state.

Agricultural wastes occur in limited quantities in the southeastern U.S., only 4 percent of what is potentially available nationwide (Miller and Schooley, 1979). In addition, southern farmers manage soils which usually are low in natural fertility, and they frequently encounter difficulties in maintaining soil organic matter at the 1 to 2 percent levels considered desirable. Both of these conditions would be aggravated by extensive use of crop residues. There may be specific situations, such as peach or pecan processing plants, where excellent opportunities for energy generation from biomass exist, but in general agricultural residues do not appear to be the most promising biomass energy source in Alabama.

Among cultivated agricultural crops, sugarcane and sweet sorghum hold considerable promise for the South. The latter is of special interest because it will grow well on a variety of sites and yields a raw material which can be harvested and converted into alcohol with currently available machinery and technology (Cochran and Ricaud, 1979). Battelle Laboratory coordinated a series of field trials in midwestern and southern states designed to determine yields of several sweet sorghum cultivars grown under differing cultural treatments (Lipinski et al., 1979). On a Mississippi River bottoms site, for instance, dry biomass yields ranged from 5.6 to 10 tons per acre in this study.

Forest vegetation probably constitutes the most promising terrestrial biomass energy source for Alabama. Two-thirds of the state's area is forest land and its hardwood and softwood inventory have been increasing steadily for more than two decades, even though Alabama already generates more timber products than any other state in the Mid-south (Beltz, 1975).

Energy from forest vegetation can have several origins, the most important one currently is generated in manufacturing processes and consists of lignin, bark, shavings, sawdust or chips. Less raw material is also wasted during harvesting operations in the woods today; tops and root systems are increasingly gathered, chipped and processed. In a logical extension of this whole-tree utilization, whole-stand utilization

is rapidly coming of age and trees which previously were considered culls because of species, size or condition are now harvested. Karchesy and Koch (1979) describe the extent of this resource for Southern pine sites and conversion processes for it ranging from industrial burning systems to gasification, pyrolysis, and fermentation. A harvester prototype developed by Koch and Savage (1980) and the Forest Service in association with a consortium of forest industries is currently being tested.

Short-rotation coppice forests also are a likely future source of energy derived from woody biomass. They consist of closely spaced, cultivated plantations of broadleaved trees harvested every ten years or less and regenerated by sprout growth from the rootstocks (Brown, 1976; Fege et al., 1979). Yields from coppiced sycamore trials in the Piedmont of Georgia ranged between 3.0 and 5.8 tons of dry matter (without leaves) per acre per year, depending on plantation spacing and the length of harvesting cycles (Steinbeck and Brown, 1976). Ranney and Cushman (1980) have identified the coastal plains as the most likely sites for wood energy plants in the southeastern states. This assessment was based largely on the land resource capable of supporting short rotation forests and the availability of forest residues in this region.

OUTLOOK

Biomass is emerging as a renewable, ecologically acceptable alternate energy source in rural regions of the United States. It appears especially promising in the Southeast with its long growing season and moist climate and has already become a partial substitute for increasingly scarce fossil fuels. Today, most of this biomass energy in the region is derived from forest vegetation and this trend will continue because of the land use patterns, soils, and dominant vegetation of the area.

Much of the "energy wood" will be provided by the better utilization of commercial forest stands and the harvesting of others which currently have no markets. Manufacturing wastes will probably decrease in importance because of better technologies and more complete wood utilization in reconstituted products. Biomass farms may come on stream after the turn of the century, although the raw materials produced in them likely will be converted into a variety of end products, including energy.

As is true for any new enterprise, information needs are many and varied. One of the most pressing ones is for pilot conversion plants for liquid and gaseous fuels. Techniques for complete biomass inventories of forest stands and indices for the biomass production potential of different soils must be developed. Species screening programs for agricultural, herbaceous and forest tree species will continue to determine yields, crop requirements and energy balances. We have barely begun these research tasks and much remains to be done before biomass can reach its full potential as an alternate energy source.

Biomass Energy Sources

REFERENCES

- Anonymous. 1974. Census of Agriculture, State and County Data: 1(1) U.S. Dept. of Commerce, Bureau of the Census.
- Anonymous. 1979a. The good news about energy. Council on Environmental Quality, 722 Jackson Place, N.W., Washington, D.C. 20006. 55pp.
- Anonymous. 1979b. Forest biomass as an energy source. Soc. of Am. Foresters, 5400 Grosvenor Lane, Washington, D.C. 20014. 7pp.
- Beltz, R. C. 1975. Alabama's timber resources updated, 1975. USDA For. Serv., South. For. Expt. Sta. Bull. SO-55, New Orleans, La. 10pp.
- Brown, C. L. 1976. Forests as energy sources in the year 2000: What man can imagine, man can do. J. For. 74: 7-12.
- Cochran, B. J. and R. Ricaud. 1979. The potential of producing and harvesting sugarcane and sweet sorghum as a renewable biomass energy source. Rept. #ORO-5373-TI, U.S. Dept. of Energy, Washington, D.C. 20585.
- Fege, A. S., R. E. Inman and D. J. Salo. 1979. Energy farms for the future. J. For. 77: 358-361.
- Hedlund, A. and J. M. Earles. 1973. Forest statistics for Alabama Counties. USDA, For. Serv., South. For. Expt. Sta. Bull. SO-39, New Orleans, La. 41pp.
- Hertzmark, D. I. 1979. A preliminary report on the agricultural sector impacts of obtaining ethanol from grain. Report #SERI/RR-51-292, Solar Energy Research Institute, 1536 Cole Blvd., Golden, Colo. 80401. 21pp.
- Karchesy, J. and P. Koch. 1979. Energy production from hardwoods growing on Southern pine sites. USDA, For. Serv. Gen. Tech. Rep. SO-24, South. For. Expt. Sta., New Orleans, La. 59pp.
- Koch, P. and T. E. Savage. 1980. Development of the swathe-felling mobile chipper. J. For. 78: 17-21.
- Lipinski, E. S., D. R. Jackson, S. Kresovich, M. F. Arthur, and W. T. Lawhon. 1979. Carbohydrate crops as a renewable resource for fuels production. Rept. #BMI-2031(1), U.S. Dept. of Energy, Washington, D.C. 20585.
- Miller, K. A. and F. A. Schooley. 1979. The report of the alcohol fuels policy review. Raw material availability reports. Rept. #DOE/ET-0114/1, U.S. Dept. of Energy, Washington, D.C. 20585.
- Ranney, J. W. and J. H. Cushman. 1980. Regional evaluation of woody biomass production for fuels in the Southeast. Biotechnology and Bioengineering (supplement). In press.

Klaus Steinbeck

- Saterson, K. A., M. K. Luppold, K. M. Snow and R. E. Lee. 1979.
Herbaceous species screening program. Phase I, Final Report.
Rept. #C00-5035-3. U.S. Dept. of Energy, Washington, D.C. 20585.
- Steinbeck, K. and C. L. Brown. 1976. Yield and utilization of hardwood
fiber grown on short rotations. Appl. Polymer Symp. 28: 383-401.

ENERGY: NEED VERSUS DEMAND¹

Edward Passerini²
New College
University of Alabama
University, AL 35486

INTRODUCTION

This evening I will briefly examine four areas. First, we will see that a number of countries are living better than we do on less energy per capita. Second, we will look at some areas where massive energy conservation will benefit us not only directly, but also indirectly by lowering pollution and reducing unemployment. Third, we will try to understand that intelligent policies and technologies can dramatically reduce our energy use and still keep our quality of life high. Fourth, we will examine the technologies which provide the best *net* energy for the future. But first we must define some terms.

(1) *Need, Demand and All That*

The "needs" of an individual or a nation depend upon her perception and situation; if you have a well-insulated house, you do not perceive as much need for heating capacity; if your nation drives small cars, you don't need as much gas. "Demand" is a different story, and we must first understand that economists define "demand" as a need which *can* be satisfied by economic measures. Thus, there is little "demand" for food in Bangladesh; they may "need" food but if they can't pay for it, then there is no "demand." It should also be clear that advertising can create a "demand" for a product where there is no need; in fact, this is the function of advertising. Thus we have hula hoops, 2-ton cars, and a "throw-away" society--increasing "demand" for what Thorsten Veblen called "ever-more-ephemeral goods." The more quickly the goods are discarded and replaced, the faster GNP rises and thus GNP has been described as "a

¹An invited paper presented at the 1980 Annual Meeting of the Alabama Academy of Science Symposium on Energy and Alabama at Samford University, Birmingham, Alabama, March 22, 1980.

²Dr. Passerini is a Professor of Humanities and Environment at the University of Alabama. He is well-known in the state as Host of a weekly educational television program entitled "The Environment," which ran from 1973-79. His educational background involves degrees in both physics and literature. His current activities range from solar home research to construction of an ultra-safe electric car.

measure of the rate at which a nation destroys things." Thus to get an accurate measure of how well people are actually living, we must use a different and better measure, such as Net National Product (GNP minus Gross Discarded Product) or the Lasting Goods Index (a crunching of four pieces of data: owned houses/capita, TVs/capita, boats/capita, bathtubs, showers/capita) or the Physical Quality of Life Index (a crunching of longevity, literacy and infant mortality figures). Since the last mentioned, P.Q.L.I., has the best correlation with standard of living, we will now compare it with energy use.

(2) Energy Use Versus Quality of Life

Energy producers are fond of claiming that more energy use contributes to a better quality of life. This is apparently true up to about 0.2 Quads per year per million people. After that, the relationship seems to be negative.¹ Since U.S. currently uses about .4 Quads per million people per year, it would appear that we are well beyond the point where more energy use will benefit us. Indeed, with all the problems that are now appearing in the nuclear, coal, and oil industries, we would probably be wise to cut back sharply on our energy use. The question is: Where should we cut back and what will be the results?

(3) Massive Conservation Areas

The cheapest form of energy is conserved energy. For example, current projections are that a nuclear power plant begun June 1, 1979 would cost \$2.50/watt to build and over \$10/watt to operate during its 30 year lifetime. Photovoltaic cells are also in the neighborhood of \$10/watt. By contrast, a watt of generating capacity can be saved by insulating houses, making industrial processes more efficient, etc. for about \$1 per watt. The problem is that the home-owners and small businessmen do not have the capital to invest. The large energy companies do have the capital, but they are reluctant to spend it for services such as insulation which are dispersed and, once dispersed, uncontrolled. Instead of embarking on an \$88 billion synthetic fuels program--which yields much less energy at higher costs than conventional fuels--an \$88 billion conservation program would yield much better results, i.e. more energy conserved than could be produced with the money. The task is to make Congress aware of this situation and to be able to override the votes of those Members of Congress who are more influenced by the energy companies than by the "common good."²

A large conservation program would make it possible to reduce energy consumption in the following areas:

(a) New electric capacity. In fact, we could probably eliminate new electric capacity *without* a conservation program. The Federal Power Commission recommends a reserve electric capacity of 18% and our current reserve is 36%. Since the curve of electric use increase has been constantly downward this decade, it is entirely possible that it will reach zero or even drop below zero before the reserve capacity drops to 18%. Electric companies are already wondering if the plants they are currently building are realistic.³

Energy: Need Versus Demand

(b) *Old electric capacity.* A number of conservation scenarios could lead to phasing out older (inefficient and high-pollution) coal-fired power plants. The scenarios include policies leading to flat rates, disincentives for all-electric homes, decreasing needs for electric-intensive materials (e.g., container legislation) and similar "California" policies.

(c) *A move to produce American cars which can regain the 28% of the market lost to foreign cars.* Similar moves in other industries could result in smaller, more efficient appliances which require less energy to manufacture and to run.

(d) *Home retrofits.* Eighty-eight billion dollars divided by 50 million homes is over \$1,000 per home. A large campaign (WPA or CCC style) to insulate, weather-strip, install double/storm windows would result in significant energy savings, as it has in Sweden, Switzerland and other countries with strong insulation standards.

(4) Energy Projections

The United States currently uses about 80 quads per year. Projections for U.S. energy use in the year 2000 have ranged from 190 quads down to 10 or 15 quads. Amory Lovins has put together an interesting matrix showing who made which projections when. Noting that one of the Huxleys believed that "all knowledge is fated to begin as heresy and end as superstition," Lovins has grouped the projections according to whether the groups making the projections seem to represent an entrenched superstition, conventional wisdom, heresy, or a fourth category called "beyond the pale."

Year of Forecast	Source and Size of Forecast			
	Beyond the Pale	Heresy	Conventional Wisdom	Superstition
1972	125 (Lovins)	140 (Sierra Club)	160 (AEC)	190 (FPC)
1974	100 (EPP, ZEG)	124 (EPP)	140 (ERDA)	160 (EEI, EPRI)
1976	75 (Lovins)	89-95 (Von Hippel)	124 (ERDA)	140 (EEI)
1978	33 (Steinart)	63-77 (Conaes I&II)	96-101 (Weinberg)	124 (LAPP)
1980	10-15 (Lovins)			95 (Schlesinger)

Notice that this is a diagonal matrix; every two years the projections move one column to the right so that the 1972 projection by Lovins, an energy "dove," appears in the far right column by energy "hawk" Ralph Lapp eight years later. By then, Lovins was projecting a mere 10-15 quads. It is clear that all four groups are revising their projections downward and that Lovins is leading the pack.⁴ Of course, no one knows where it will stop but it is clear that there are some easy ways to drastically cut our energy use. A random sample follows. (a) Shifting from trucks to trains not only increases the ton-miles per gallon of fuel by a factor of four to six, but also eliminates the destruction of our highways--the impact of a single 18-wheeler is equivalent to the impact of 10,000 automobiles. Our asphalt and concrete highways are one of our most energy intensive industries.⁵ (b) Thermoelectric refrigerators with the thermocouples on top and redesigned shelves are *at least* four times as efficient.⁶ (c) A national bottle law would save enough energy annually to provide the annual electricity for our state and a couple others.⁷

I think you can see that it is possible to save large chunks of energy without sacrificing quality of life. Indeed, if we are willing to admit that other countries may be doing better than we are, then it is possible to enjoy a *higher* quality life while cutting down energy use, reducing dependency on foreign oil, reducing unemployment (see WPA-style project above) and using more efficient appliances. In sum, conservation is the way to go.

(5) *Solar Energy*

By "solar energy," I mean *direct* use of solar energy on site; I do *not* mean biomass, ocean thermal, off-shore wind, alcohol, space platform solar satellites, or tower power--these are inefficient means of producing power. Direct, on-site solar energy is extremely efficient. For example, a solar water heater typically pays back the *energy* that went into its manufacture in about two years. No conventional energy source (let alone syn-fuels) can make anything like that statement. Current photovoltaic cells also have an energy payback of about two years--contrary to rumors that keep circulating that they never earn back their manufacturing energy. In fact, the new Spectrolab cells have an energy payback of three months and Peter Glaser computes the theoretical minimum at about a week.⁸ *Direct* use of solar energy is the best means we have for producing large amounts of *net* energy.

NOTES

1. Data from United Nations. P.Q.L.I. is the Physical Quality of Life Index, now accepted by most sociologists as being a much better predictor of living standard than is GNP/capita or income/capita--although GNP/capita and income/capita plotted against energy use/capita shows a similarly "humped" curve, as does the Lasting Goods Index.
2. Further details on the economics of conservation are available in Hayes, Denis, *Rays of Hope*, Norton 1977.

Energy: Need Versus Demand

3. Data from Federal Power Commission. Conclusion based on recent issues of *EPRI Journal* and *Nucleonics Week*.
4. Data from Lovins, Amory, "Getting Efficient," *Rain*, November 1979.
5. Data from recent studies by Bruce Hannon, Center for Advanced Computation, University of Illinois, Urbana, Illinois.
6. Lovins, "Getting Efficient."
7. Data from Hannon (op. cit.) and Nelson, Sandra, Environmental Action Foundation, 1346 Connecticut Avenue N.W., Washington, D.C. 20036.
8. Data from Stephen Lyons, *Sun*, FOE (124 Spear Street, San Francisco, California 94105), 1978 and Hayes, (op. cit.) pp. 229-230. Interesting papers on this subject include: Odum, Howard T., "Energy Economics and Ecology," *Ambio*, Vol. 3, No. 6, Daneker, Gail, "Jobs and Energy," EEF, 1785 Massachusetts Avenue N.W., Washington, D.C. 20036.

ENERGY AND ECONOMICS¹

Donald R. Street²
Department of Economics
Auburn University
Auburn, AL 36830

INTRODUCTION

It is not possible to give an overview of the state of development of energy economics in the space allocated for this presentation. The many energy sources discussed in our symposium will have certain peculiarities with respect to details on their development and use. The basic economics to be applied is largely the same, however. The economics of energy is unique in that it applies to all of us. The latter attribute gives it special attraction to emotional appeal which at times causes one to let go of reason.

Economics related to energy has become very important since our economy has energy's effects built into its total fabric. It is critically important in that we have ceased to be an inside-directed economy and have become outside-directed largely because of dependence on foreign petroleum sources for a sizable proportion of our supplies. We must be careful, however, not to use energy problems as an excuse or as a disguise to cover economic policy incompetence in other parts of the economy. We could blame energy for the 18 percent inflation rate existing in the U.S. early in this year. The experts have shown that if we eliminated the effects of energy, housing and food from the data, we would still have an inflation rate in the 8 to 10 percent range just on the ordinary items of life.

On energy economic matters the enemy has been among us over the years and the enemy has been largely us. Serious mistakes have occurred because of lack of economic knowledge, because of not applying what is well-documented by empiricism and because of ignorance of the values of

¹An invited paper presented at the 1980 Annual Meeting of the Alabama Academy of Science Symposium on Energy and Alabama at Samford University, Birmingham, Alabama, March 22, 1980.

²Dr. Street is an Associate Professor in the Department of Economics at Auburn University. Trained in Resource Economics, he has extensive research experience in land and water use on economic development. He has recently been involved in investigating the socio-economic effects of nuclear power and the use of electricity by low-income consumers.

various relationships in the field. The political process is entangled in all three of these difficulties. The literature has been full of cases such as price ceilings causing excessive waste of fuels while at the same time preventing exploration of resources to help provide a degree of independence on energy matters. There is certainly nothing holy about independence, and if the idea is pushed too far, it gets in the way of the obvious benefits of trading to exploit comparative advantage.

Economics was rather late in being applied to energy. Long-term declining prices such as were experienced in the electricity market for the last 35 or so years preceding the 70's were hardly the stimulus expected to elicit such a response. The energy crunch in 1973 brought home an awareness of the problem, leading to a search for relevant guidelines and new approaches with better data. There is a cost to getting good information on a subject. The expected benefits must exceed the expected cost for additional information or the appropriate party will not pursue the matter further. No doubt this feeling led to the lack of good demand data and elasticity data specifically, as energy producing firms were doing quite well in the decades preceding the 70's.

Until recently economists felt that if they could get non-business scientists to understand supply and demand, they would have made great progress in enlightening the public on energy matters. It was not uncommon to project "demand" as a trend line into the future, nothing else being said, with the implicit assumption that the price would be the same. The fact is that demand has two variables, a price and a quantity, with certain other variables held constant. The whole demand function family can be shifted upward or downward by changing any one of these other variables.

It is now widely recognized that economics is our lifeblood in energy, whether we like it or not. Solar energy, regardless of its technological possibilities, ultimately depends on economics completely for its directive. Otherwise it is a hobby that is possibly very costly. The same can be said with respect to coal use, nuclear power, biological sources, conservation and strip mining. Attempts to allocate on the basis of "need" rather than "demand" are attempts to establish ourselves as God over our fellowmen.

On the theoretical level, supply and demand in both the final product and in the factor of production market will take care of most issues, while proper handling of "externalities" will help to solve many other problems of a "social" nature. After this point, empiricism prevails, still leaving room for some element of disagreement on allocations and actions according to how much information is enough.

Alabama is fortunate in having a large amount of conventional energy sources such as coal, hydroelectric power, and more recently oil. We also have a very large component of nuclear power with its corresponding advantages and disadvantages when compared with other energy sources. Our ability to meet imminent challenges will be enhanced by careful consideration of all relevant variables.

VIEWS ON ENERGY ECONOMIC PROBLEMS

Many questions continue to emerge on what will happen tomorrow in the energy field. Divergent views abound on the type of economic world we will be living in. Pressures to internalize certain social costs in the price of products to reduce damages to the public have finally emerged. This question will be dealt with in the following paragraphs along with questions on allocating our energy resources by different methods.

The problems in energy relating to social costs, externalities, or spillovers were not discovered yesterday. In 1920 A. C. Pigou shed a great deal of light on distinguishing the social and the private net social product of enterprise.¹ Later, Ronald Coase² and Francis M. Bator³ covered and improved the theory by contributing literature on social cost and market failure, respectively. James M. Buchanan and William Craig Stubblebine⁴ discussed similar topics in great detail. David Whitcomb⁵ wrote a complete book on externalities in 1972, hence there has been no dearth of theoretical backing for thinking related to environmental effects on energy problems.

The term "social cost" may have several different connotations in current use, but they always relate to the same phenomenon. Two of the uses are spelled out below. One of the views would designate "social" cost to be that part of the total which is incurred by the public generally in the form of environmental damage to nearby parties. This part of the cost would not be built into the price of the product as would the "private" elements of the total. The second view, one used by most economists, would designate "social" cost to be the total. Its components would be the "internal" elements, those covered by the firm in the cost of the product without any coercion, and the "external" ones, those imposed on the public. These two views are shown in Figure 1. The net result is the same in either case, but one must be aware of the different uses of the terms within the proper context in the literature. The implications are that when these "social" or external costs are

COSTS

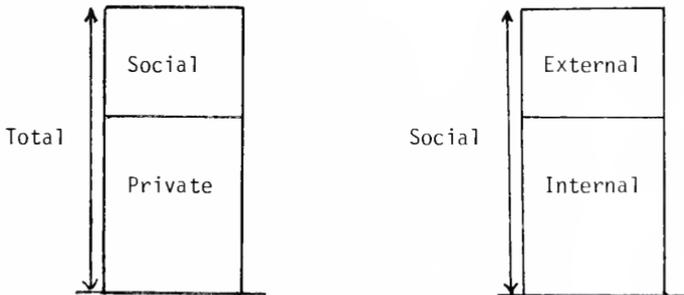


Figure 1. Two Views of the Term "Social Cost."

covered, the price of the product must increase. The price of coal must be raised to cover land reclamation; the price of electricity must be raised to cover the cost of electrostatic precipitators, scrubbers, cooling towers, and safety. This trend to internalize all costs into the price will therefore raise the final product price above and beyond its level without the internalization.

There remains a problem in educating the public to this fact. The problem is made more difficult by vote-hungry politicians promising to reduce utility bills, inciting the populace to disillusionment as truth is ultimately discovered.

A great deal of concern has been expressed recently with respect to the depletion of exhaustible resources. Robert M. Solow reports that Harold Hotelling had largely solved the rate-of-use problem on this matter as reported in the *Journal of Political Economy* back in 1931. According to Solow,

The only way that a resource deposit in the ground and left in the ground can produce a current return for its owner is by appreciating in value. Asset markets can be in equilibrium only when all assets in a given risk class earn the same rate of return, partly as current dividend and partly as capital gain. The common rate of return is the interest rate for that risk class. Since resource deposits have the peculiar property that they yield no dividend so long as they stay in the ground, in equilibrium the value of a resource deposit must be growing at a rate equal to the rate of interest. Since the value of a deposit is also the present value of future sales from it, after deduction of extraction costs, resource owners must expect the net price of the ore to be increasing exponentially at a rate equal to the rate of interest.⁶

Solow later, and still following Hotelling's ideas, states that, "If net price is increasing like compound interest, owners of operating mines will be indifferent at the margin between extracting and holding at every instant of time."⁷

Technological change could, of course, change the economic prospects and hence the optimum rate of development. New technological breakthroughs in energy could establish a sort of ceiling for the price of imported petroleum. Solow warns, however, that if a coal liquefaction plant, for example, were built here based on high monopoly profits by the exporter, a sudden decrease in prices of petroleum would jeopardize the U.S. venture.⁸

Our grandchildren ultimately enter into any discussion of the use of non-renewable natural resources. Roger Leroy Miller says,

First, the well-being of future generations largely depends on our saving behavior, and conservation may take place in the absence of any real savings. Second, even if I am

ninety years old, I intensely care for future generations because the present value of my oil wells which determines my immediate consumption, depends on rationing the oil output among individuals that will stay alive after I am gone.⁹

He clears up a common misconception by stating that "Conservation means the optimal timing of the use of our fixed amount of resources."¹⁰

Solow aptly points out that "There is no way to collect bids and offers from everyone who will ever live." and that ". . . It does seem fundamentally implausible that there should be anything ex post right about the weight that is actually given to the welfare of those who will not live for another thousand years. We have actually done quite well at the hands of our ancestors. Given how poor they were and how rich we are, they might properly have saved less and consumed more."¹¹

Solow's article was inspired, in part, by *The Limits To Growth* by Donella H. Meadows, Dennis L. Meadows, *et al.*¹² During the "awareness of scarcity" era to date, largely from the late 60's through the 70's, the literature has been full of offshoot solutions to energy and environmental problems, some of which ignore conventional economics or attempt to supplant it. Several economists such as Kenneth Boulding and John Kenneth Galbraith have furnished a considerable amount of reading matter along these lines. In the 60's Herman E. Daly began pushing his Steady-State living plan and spent several articles defending it.¹³ He is perhaps representative of this group. According to Daly,

The steady-state economy is a physical concept. It is defined by constant stocks of people and physical wealth (artifacts) maintained at some chosen, desirable level by a low rate of throughput. The throughput flow begins with depletion (followed by production and consumption) and ends with an equal amount of waste effluent or pollution. The throughput is the maintenance cost of the stock and should be minimized for any given stock size, subject to some limits stemming from the legitimate need for novelty.¹⁴

He has some interesting ideas in his protests toward conventional economics and humanity in general. His low regard for current expertise and technology is illustrated by his statement that, "At this point the growthmaniacs usually make a burnt offering to the god of technology: surely economic growth can continue indefinitely because technology will continue to grow 'exponentially' as it has in the past."¹⁵

In directing back to his steady state, Daly would create institutions for stabilizing population, physical wealth and limiting inequality of the wealth. His system is based on private property type bids and "control of aggregate births (marketable birth license plan as first proposed by Boulding) and control of aggregate depletion of basic resources (depletion quotas auctioned by the government).¹⁶

No attempt will be made here at delving into fine points of the plan of Daly and his disciples, but no doubt they will pick up a greater

following in the future. I see somewhat more morality in many technologists than Daly seems willing to admit, however.

THE FUTURE

Our accomplishments and opportunities are open to subjective interpretation, but we really are making considerable progress in the energy utilization process because of the price system working. Tremendous progress is now being made in automobile fuel conservation. Most companies (Chrysler being an exception) saw the handwriting on the wall and made needed orderly adjustments. The switches to Diesel power are brought on by the price increases in fuel. Weight reductions of vehicles is another similar example. Given time, more switches will be made and other significant innovations and design changes will be made. Housing is another energy user with unlimited opportunities to change for the better because of the price system working. Aside from any tax-advantage incentives, the inducements of price will bring in insulation, storm windows, and will ultimately utilize waste heat from heat pumps to heat water for many homes. These technical improvements can be expanded greatly by proper legislative inducements on building standards, by expanded knowledge on energy use of appliances, and by general education on energy efficiency, but the ultimate key to response is the working of the price system.

In industry, hundreds of method changes are taking place to conserve energy. Use of byproduct heat for useful work is but one example. Industrial heat pumps are being put to use. Use of hot water waste to grow fish and other sea products more efficiently in cold weather is another example of energy conservation and of a way to turn a potential pollutant into a benefit. The price of the product and the value of the resources are the incentive to action. Valuable suggestions by the Ford Foundation Committee's book, *A Time to Choose*,¹⁷ have already been put into effect and others will go into effect with sufficient time and price incentives.

We still face a number of challenges in the energy field. A national energy policy is now emerging, yet it will take a considerable amount of time for its impact to be felt. France is moving ahead very rapidly on nuclear power, including the breeder reactor, while the U.S. is trying to recover from its Three-Mile Island encounter.

Safety in nuclear power is and will be of great concern in the future. Internalizing is good, but if we build in too much protection, it is costly to society in the same manner as if we did not build in enough. The idea that more is always better is not appropriate to internalizing the would-be spillovers. If marginal benefits for a dollar used in enforcing jaywalking laws are greater than the marginal benefits of a dollar put into increased safety in nuclear plants, more dollars should be put on the former endeavor and less should be put on the latter.

One of the most difficult problems in energy is that of conflicting policies from government. Conservation has been pushed as a national goal by three presidents, yet we have contradictory payments to induce

persons to use more energy. Payments during election year should be viewed with some skepticism. At best, this approach seems to be treating a symptom rather than a disease. Politics will often prevail over economics, however.

Data problems are still very prevalent in the energy field, especially with respect to consumer responsiveness or elasticity of demand. Good policies cannot be formed without a better base on which to plan.¹⁸

Alabama's future welfare depends upon her wise use of the resources at hand. Being prepared to know the effects of policies will enhance the orderly and appropriate development of our state.

NOTES

1. A. C. Pigou, *The Economics of Welfare* 4th ed. (London: McMillan and Co. Ltd., 1962).
2. Ronald Coase, "The Problem of Social Cost," *Journal of Law and Economics*, October 1960.
3. Francis M. Bator, "The Anatomy of Market Failure," *The Quarterly Journal of Economics*, August 1958.
4. James M. Buchanan and William Craig Stubblebine, "Externality," *Economica*, November 1962.
5. David K. Whitcomb, *Externalities and Welfare* (New York: Columbia University Press, 1972).
6. Robert M. Solow, "The Economics of Resources or the Resources of Economics," *American Economic Review*, May 1974, p. 2.
7. *Ibid.*, p. 3.
8. *Ibid.*, p. 5.
9. Roger LeRoy Miller, *The Economics of Energy* (New York: William Morrow and Company, Inc., 1974), p. 59.
10. *Ibid.*, p. 56.
11. Solow, *op. cit.*, p. 9.
12. D. H. Meadows, *et al.*, *The Limits of Growth* (New York: Universe Books, 1972).
13. Herman E. Daly, "On Economics as a Life Science," *Journal of Political Economy*, May-June 1968, 76, pp. 392-402.
14. Herman E. Daly, "In Defense of a Steady-State Economy," *American Journal of Agricultural Economics*, December 1972, 54, 5, p. 945.

Energy and Economics

15. Herman E. Daly, "The Economics of the Steady State," *The American Economic Review*, May 1974, p. 18.
16. *Ibid.*, p. 19.
17. Energy Policy Project, The Ford Foundation, *A Time to Choose* (Cambridge: Ballenger Publishing Company, 1974).
18. Wayne Lacy and I have established that in residential electricity use, families with less than \$3,000 income are about four times as responsive to price changes as are families of over \$25,000 income. Income-segmented data are needed on many other energy factors to determine responsiveness and appropriate policies. See A. Wayne Lacy and Donald R. Street, "The Residential Demand for Electricity by Income Class," *Midsouth Journal of Economics*, 3, 1, 1979, p. 27.

EFFECT OF TOPSOILING ON ALABAMA-AREA-BITUMINOUS-COAL-MINING PRODUCTION COST¹

J. Earl Bailey²

*Department of Aerospace Engineering
University of Alabama
University, AL 35486*

and

Walter Misiolek³

*Department of Economics
University of Alabama
University, AL 35486*

INTRODUCTION

The objective of this paper is to analyze incremental costs of bituminous coal mining which result from the topsoiling requirement of the Surface Mining Control and Reclamation Act of 1977. Motivation for analyzing topsoiling costs lies in the controversy surrounding Alabama coal industry compliance with 1977 act topsoiling requirements. Some of the Alabama industry has been slow to meet or has actively opposed (sometimes through the courts) the 1977 act requirements, possibly because of some of the following reasons:

1. A sincere belief that use of subsoils can in some instances provide a better growing medium than A or B horizon soils.
2. A belief, sometimes erroneous, that the A and B horizon soil layers are too thin or simply do not exist in many Alabama situations.
3. That the incremental costs of topsoiling would make the Alabama industry non-competitive with other states that surface mine thicker coal seams on the average.

¹An invited paper presented at the 1980 Annual Meeting of the Alabama Academy of Science Symposium on Energy and Alabama at Samford University, Birmingham, Alabama, March 22, 1980.

²Dr. Earl Bailey is a Professor in the Department of Aerospace Engineering, Mechanical Engineering, and Engineering Mechanics at the University of Alabama. His area of specialty is optimization, control, and systems analysis. During the past 10 years he has conducted research on the application of systems analysis methodology to environmental impact and ecological systems problems.

³Dr. Misiolek is an Assistant Professor in the Department of Economics at the University of Alabama. His area of speciality is environmental, natural resource economics, public finance, and monetary policy.

Topsoiling and Bituminous Coal Mining

Topsoiling has been widely used in land restoration by the construction, road building, and horticulture industries. Comments on the desirability of topsoil conservation in mining by Dr. D. E. McCormack, U.S. Department of Agriculture (Reference 1) are as follows:

For several decades, the federal government, as well as state and local governments, have directed substantial efforts toward keeping the productive surface horizons of our soils in place, preventing their erosion and the resulting reduction in productive capacity of the soil.

...We wish to make it clear at this point that the surface horizons to which we refer are those organically enriched layers that received and accumulated the residues of the native plants through the many thousands of years of soil formation.

...Burying the A horizons under many feet of spoil during the surface mining operation is certainly not compatible with full restoration of the productive potentials.

...The soil microorganisms, concentrated in the A horizon, are vital to both the chemical and physical properties of the natural soil. Only by special handling of the material from the A horizons can a few of these microorganisms be preserved to inoculate the final soil after mining.

In addition to the topsoil attributes of organic matter, microbiological diversity, and nutrients, the water retention capability of topsoil is important to mine reclamation.

The topsoil replacement requirement in Public Law 95-87 (Surface Mining Control and Reclamation Act of 1977, Reference 2) is as follows:

(5) remove the topsoil from the land in a separate layer, replace it on the backfill area, or if not utilized immediately, segregate it in a separate pile from other spoil and when the topsoil is not replaced on a backfill area within a time short enough to avoid deterioration of the topsoil, maintain a successful cover by quick growing plant or other means thereafter so that the topsoil is preserved from wind and water erosion, remains free of any contamination by other acid or toxic material, and is in a usable condition for sustaining vegetation when restored during reclamation, except if topsoil is of insufficient quantity or of poor quality for sustaining vegetation, or if other strata can be shown to be more suitable for vegetation requirements, then the operator shall remove, segregate, and preserve in a like manner such other strata which is best able to support vegetation;

(6) restore the topsoil or the best available subsoil which is best able to support vegetation;

(7) for all prime farm lands as identified in section 507 (b)(16) to be mined and reclaimed, specifications for

soil removal, storage, replacement, and reconstruction shall be established by the Secretary of Agriculture, and the operator shall, as a minimum, be required to--

(A) segregate the A horizon of the natural soil, except where it can be shown that other available soil materials will create a final soil having a greater productive capacity; and if not utilized immediately, stockpile this material separately from other spoil, and provide needed protection from wind and water erosion or contamination by other acid or toxic material;

(B) segregate the B horizon of the natural soil, or underlying C horizons or other strata, or a combination of such horizons or other strata that are shown to be both texturally and chemically suitable for plant growth and that can be shown to be equally or more favorable for plant growth than the B horizon, in sufficient quantities to create in the regarded final soil a root zone of comparable depth and quality to that which existed in the material separately from other spoil, and provide needed protection from wind and water erosion or contamination by other acid or toxic material;

(C) replace and regrade the root zone material described in (B) above with proper compaction and uniform depth over the regraded spoil material; and

(D) redistribute and grade in a uniform manner the surface soil horizon described in subparagraph (A)

The topsoil handling requirements (Surface Mining Reclamations and Enforcement Provisions, Reference 3) are stated in Appendix A.

COAL SURFACE MINING ECONOMIC MODEL

During the past year, under the sponsorship of the School of Mines at the University of Alabama (Mineral Resources Research Institute-- Summer, 1980), a joint effort between the College of Engineering and the College of Commerce and Business Administration has developed and verified a surface-mining-process engineering and production-cost computer model hereafter referred to as Parametric Analysis of Surface-Mining Economics (PASME).

PASME is implemented on two University of Alabama computers. The University Computer Center UNIVAC 1110 version features interactive operator-control of parametric studies and automatic plotting of three-dimensional parametric data using the facility Zeta plotter.

The Aerospace Engineering, Mechanical Engineering and Engineering Mechanics Hybrid Simulation Laboratory version of PASME is implemented on a PDP11/34 digital computer and features interactive operator-control of parametric studies and a graphics display system that can be

Topsoiling and Bituminous Coal Mining

video-taped for generation of executive summaries, training-course tapes, or other formal presentations.

Compartmentments of the PASME model include the following:

1. Land-area requirements for mine development.
2. Exploration drilling.
3. Topsoil removal and replacement.
4. Drilling and blasting of overburden.
5. Overburden excavation and equipment selection.
6. Drilling and blasting of coal seam.
7. Coal loading costs and equipment selection.
8. Coal hauling costs and equipment selection.
9. Spoil backfill and grading.
10. Soil amendments and revegetation.
11. Present value of investments.
12. Annual labor requirements and payroll.
13. Annual cash operating expenses.
14. Annual depreciation and non-cash operating expenses.
15. Production costs per ton of coal.

The PASME model integrates land-reclamation procedures with basic coal-extraction operations. Incremental costs of alternative land-reclamation requirements can be calculated through a comparison of whole-mine production costs with each regulatory option in effect. This method presents a more accurate picture of land-reclamation costs than can be obtained from analysis of land reclamation in isolation from basic mining operations. The PASME system development was based on a broad range of published literature in the area of surface-mine modeling (Reference 4, 5, 6, 7).

The structure of the model reflects the basic steps in the surface mining process and model equations specify equipment used, equipment capacities, and cycle times for each of the steps in the mining process.

SIMULATION MODEL VERIFICATION

The PASME model is designed to reflect costs of the block-cut, area-mining, technique of surface mining. The user input to the model includes: mine-life production requirement (tons), mine life (years), average coal seam thickness and overburden depth (feet), desired rate of return on equity (%), debt/equity ratio, and interest rate on debt (%).

One of the accuracy checks performed during model validation was a comparison of the PASME model results with results from a study conducted by Katell, Hemingway, and Berkshire for the U.S. Bureau of Mines (Reference 8). Comparative results are presented in Table 1 for an Eastern mine, a Great Plains mine, and the University of Alabama PASME model. Good correlation with Reference 8 results was obtained using the PASME model. PASME predicted costs were slightly lower due to more efficient dragline bucket sizes being automatically chosen.

TABLE 1
VERIFICATION OF PASME MODEL

Eastern Mine: 55' overburden, 20 year mine life, bituminous coal, 15 yard coal loading shovel*

<u>Seam Thickness</u>	<u>Mine Output</u>	<u>Reference 8 Cost</u>	<u>PASME Cost</u>	<u>PASME Shovel Size</u>
4'	3.2 MMT/YR	\$9.82/ton	\$9.38	10 yd.
5'	4.0	8.09	7.93	12½ yd.
6'	4.8	6.94	6.96	15 yd.

Great Plains Mine: 70' overburden, 20 year mine life, lignite

<u>Seam Thickness</u>	<u>Mine Output</u>	<u>Reference 8 Cost</u>	<u>PASME Cost</u>
10'	3.68 MMT/YR	\$6.58/ton	\$6.11
15'	5.52	4.86	4.70
25'	9.20	3.39	3.62

* Note--Reference 1 shovel size does not change with thinner seams, and PASME *does* vary shovel size giving a cost savings. The same situation exists for the Great Plains Mine, where we also use a larger dragline for overburden removal.

SUMMARY OF RECLAMATION COSTS IN RELATED STUDIES

Since the enactment of the 1977 law there have been several major investigations to predict increases in reclamation costs which result from the more stringent requirements of the law.

In a July 1977 study prepared for the Office of Minerals Policy and Research Analysis on "Benefits-Costs Analyses of Laws and Regulations Affecting Coal" (Reference 9), strip mine reclamation costs were analyzed in light of the social benefit and cost to society of the new legislation. A summary of reclamation costs results of the preceding study is presented in Table 2. It is seen that topsoiling costs range between .8 and 1.9 percent of total mining costs per foot of topsoil reclaimed.

A study conducted by ICF, Inc. for the Council on Environmental Quality in 1977 (Reference 12) presented reclamation costs as follows:

1. Reclamation costs averaged \$1000 to \$4000 per acre in 1976 dollars, with regrading costs accounting for approximately half of the total.
2. Reference 12 cited an EPA study that presented contour regrading costs at 710-3552 dollars per acre in 1978 dollars.

Topsoiling and Bituminous Coal Mining

TABLE 2
AREA MINE RECLAMATION COSTS

Slope (deg)	Stripping Ratio	Seam Thickness	% Cost of Reclamation	% Adjusted* Cost for Topsoiling
5	15	2	3.4	1.9
5	15	4	1.7	1.0
5	20	2	3.0	1.7
5	20	4	1.6	.9**
5	25	2	2.7	1.5
5	25	4	1.4	.8
5	30	2	2.4	1.4
5	30	4	1.2	.7

* % Adjustment to conform with the * = .9 case.

** EPA topsoiling estimate.

- The incremental cost of topsoil handling in 1978 dollars per acre disturbed was presented at \$350-400 for 5 to 10 degree slope and \$525-750 for 20 to 30 degree slopes.

Production costs were not available for the mines cited in the above data so that incremental topsoiling costs could be presented on a percentage basis.

A computer simulation of bituminous coal area stripping with draglines in the Illinois Basin Region was conducted in 1977 by Fluor Utah, Inc. and Bonner and Moore Associates, Inc. (Reference 13) for the U.S. Energy Research and Development Administration. This study included a parametric analysis of effects of topsoil replacement thickness on production cost and the results are summarized in Table 3 for an Illinois mine. The nominal price per ton was \$13.10 with a reclamation cost of \$0.57/ton for a 4.3% reclamation cost as percent of production cost. Other reclamation costs per acre were \$900 for the \$13.10 production cost nominal case.

SENSITIVITY ANALYSIS USING THE UNIVERSITY
OF ALABAMA PASME SIMULATION

In order to illustrate economic aspects of topsoil conservation for the Alabama situation the PASME simulation will now be used to investigate topsoiling over a range of parameter variations in overburden depth and coal seam thickness mined. The mining situation investigated is a 1.8 million ton per year, bituminous coal area mine. A dragline is used for overburden removal and scrapers for topsoil moving. The nominal coal seam thicknesses chosen for this analysis are T = 2 and 3 feet. Typically, the average seam thickness mined in Alabama is approximately

TABLE 3

ILLINOIS MINE SENSITIVITY ANALYSIS
(4 foot coal seam with 71 foot overburden)

Topsoil Thickness (feet)	Coal Price/Ton Dollars/Ton	% Dollars/Foot from the Nominal Value
0	12.81	--
1/2	12.95	-2.2%
1	13.10	-2.3%
1 3/4	13.31	2.1%
2 1/2	13.52	2.1%

2 feet. Overburden depths of H = 80 and 100 feet are chosen as nominal values to give overburden thickness to coal seam thickness ratios in the range of 20 to 40 which are typical for Alabama bituminous surface coal mines.

The PASME simulation was used to investigate effects of overburden depth on production cost with topsoil thickness as a parameter. Computer graphics plots of PASME results are shown in Figures 1 and 2. Effects of topsoil depth reclaimed for overburden depths of 80 and 100 feet are shown in Figures 3 and 4. The tabulated data for these plots is presented in Appendix B.

Incremental costs of topsoiling for the example Alabama mine are as follows:

<u>H = Overburden Depth-Feet</u>	<u>T = Coal Seam Depth-Feet</u>	<u>% Topsoiling Cost of Production Cost/Foot of Topsoil Replaced</u>
100	2	3.3%
	4	3.2%
80	2	4.4%
	4	4.3%

These incremental percentage costs of topsoiling can be compared with the results of the U.S. Department of Interior study (Table 2) which are .7 to 1.9 percent of production cost per foot of topsoil replaced and the Bonner and Moore study (Table 3) which is 2.1 to 2.3 percent of production cost per foot of topsoil replaced. The Alabama topsoiling costs predicted from the PASME simulation are high because of features of the model which increase other reclamation equipment costs as equipment required for topsoil moving is increased. Future model improvements are planned to improve this aspect of the model.

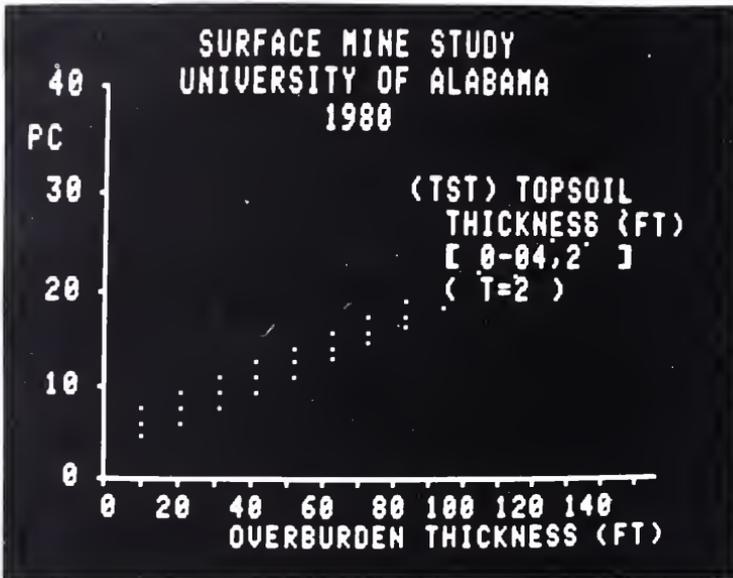


Figure 1. Production Cost as a Function of Overburden Depth and the Parameter TST = Topsoil Depth Restored (T = coal seam thickness = 2 feet)

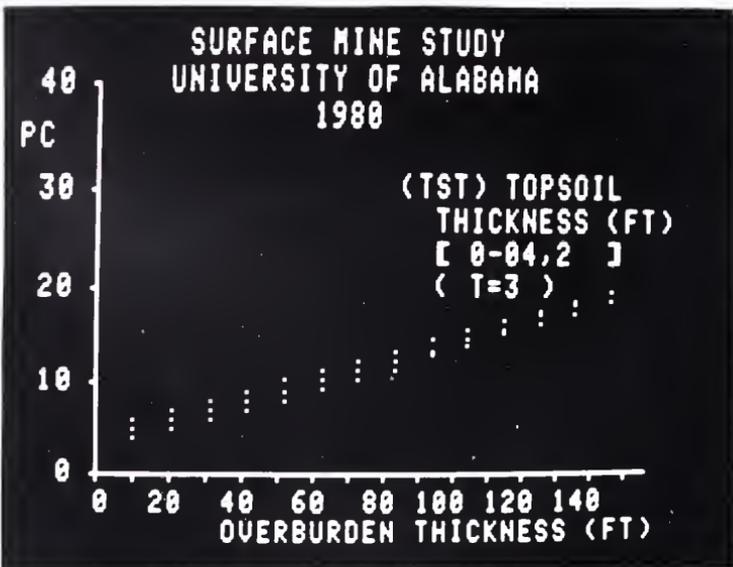


Figure 2. Production Cost as a Function of Overburden Depth and the Parameter TST = Topsoil Depth Restored (T = coal seam thickness = 3 feet)

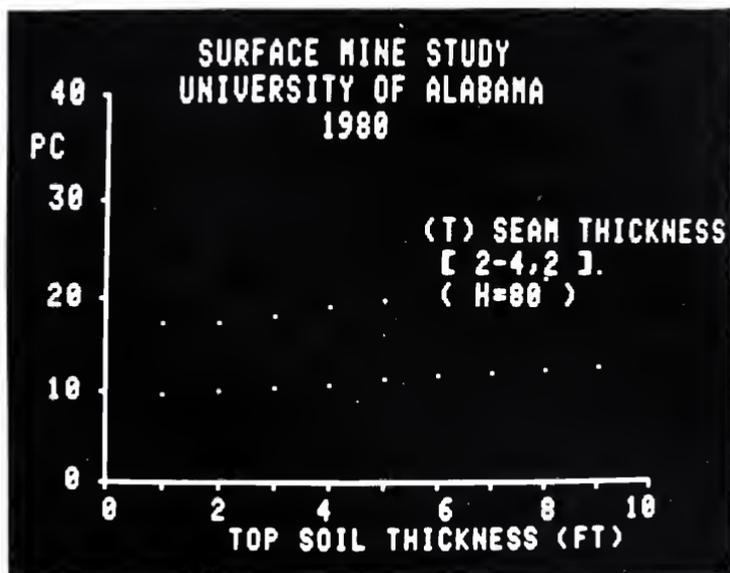


Figure 3. Production Cost as a Function of Topsoil Depth Restored and the Parameter T = Seam Thickness = 2, 4 feet (Overburden Depth H = 80 feet)

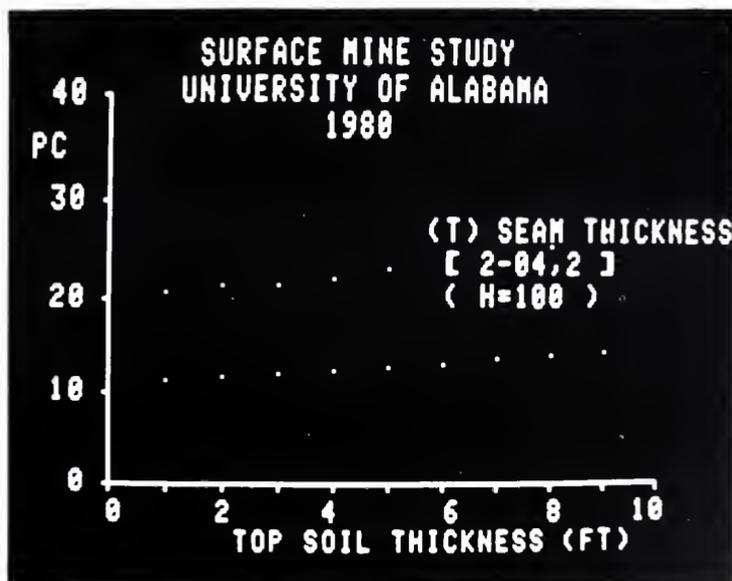


Figure 4. Production Cost as a Function of Topsoil Depth Restored and the Parameter T = Seam Thickness = 2, 4 feet (Overburden Depth H = 100 feet)

Topsoiling and Bituminous Coal Mining

CONCLUSIONS

Alabama bituminous coal surface mining costs for topsoiling to meet the requirements of Public Law 95-87 have been examined with the aid of a University of Alabama computer based simulation (PASME). Topsoiling in Alabama accounts for approximately 3 to 4% of mining production costs for one foot of topsoil replacement. This compares favorably with incremental topsoiling costs of .7 to 2.3% reported in two other studies.

If two feet of topsoil are conserved and replaced on a typical Alabama mine, incremental costs of topsoiling are approximately 6% of the production cost. This percentage is further reduced when transportation and handling costs are added to the production cost.

Justification for topsoiling lies in increased future productivity of the land, minimization of other reclamation costs such as revegetation by providing a better growth situation, and reduction of off-site environmental impacts such as siltation due to higher sustaining levels of ground cover. High level reclamation is perhaps more important in states with thin coal seams because of the high disturbed-land/coal-production-per-acre ratio. In areas with thin coal seams being mined, such as Alabama, the surface area disturbed can be dramatically larger.

SELECTED REFERENCES

1. McCormack, D. E.; "Soil Reconstruction: for the best soil after mining"; U.S. Department of Agriculture; Presented at the 2nd Research and Applied Technology Symposium on Mined-Land Reclamation; Louisville, KY; 1974.
2. Public Law 95-87; Surface Mining Control and Reclamation Act of 1977; Title V, Section 515; 3 August 1977.
3. Surface Mining Reclamation and Enforcement Provisions; Federal Register; 13 December 1977; Part II, Vol. 42, No. 239, Section 715.16; Topsoil Handling; Page 62684.
4. Skelly and Loy, Inc.; *Economic Engineering Analysis of U.S. Surface Coal Miners and Effective Land Reclamation*; Washington: U.S. Government Printing Office; 1975.
5. Tandy A. Stinnett; *Coal Mining Cost Models*; Palo Alto, California; Electric Power Research Institute; 1980.
6. E. A. Nephew and R. L. Spore; *Cost of Coal Surface Mining and Reclamation in Appalachia*; Oak Ridge National Laboratory; 1976.
7. R. F. Naill; *Managing the Energy Transition*; Ballinger Publishing Co.; Cambridge, Mass.; 1977.
8. Katell, Hemingway, and Berkshire; "Basic Estimated Capital Investment and Operating Costs for Coal Strip Mines"; Bureau of Mines Information Circular 8703; U.S. Department of the Interior; 1976.

9. Energy and Environmental Analysis, Inc. for Office of Minerals Policy and Research Analysis; "Benefit/Cost Analyses of Laws and Regulations Affecting Coal"; U.S. Department of Interior; 1977.
10. Robert J. Evans and John R. Bitler; "Coal Surface Mining Reclamation Costs"; Bureau of Mines Information Circular 8695; U.S. Department of the Interior; 1975.
11. Katell, Hemingway, and Berkshire; "Basic Estimated Capital Investment and Operating Costs for Coal Strip Mines"; Bureau of Mines Information Circular 8661; U.S. Department of the Interior; 1976.
12. Energy and Economic Impacts of H.R. 13950 (Surface Mining Control) and Reclamation Act of 1976); ICF Inc.; for Council on Environmental Quality; 1977.
13. Fluor Utah, Inc., and Bonner & Moore Associates, Inc.; for Energy Research and Development Administration; "Economics of Large-Scale Surface Coal Mining Using Simulation Models"; 1977.
14. R. Bird and W. Misiolek; *Report of Effects of Land Reclamation Policies on the Economic Feasibility of Lignite Surface Mine Development*; School of Mines and Energy Development; The University of Alabama; 1979.

APPENDIX A
Reference 3--SURFACE MINING RECLAMATION AND
ENFORCEMENT PROVISIONS

*716.16 TOPSOIL HANDLING.

To prevent topsoil from being contaminated by spoil or waste materials, the permittee shall remove the topsoil as a separate operation from areas to be disturbed. Topsoil shall be immediately redistributed according to the requirements of paragraph (b) of this section on areas graded to the approved postmining configuration. The topsoil shall be segregated, stockpiled, and protected from wind and water erosion and from contaminants which lessen its capability to support vegetation if sufficient graded areas are not immediately available for redistribution.

- (a) TOPSOIL REMOVAL. All topsoil to be salvaged shall be removed before any drilling for blasting, mining, or other surface disturbance.
 - (1) All topsoil shall be removed unless use of alternative materials is approved by the regulatory authority in accordance with subparagraph (4). Where the removal of topsoil results in erosion that may cause air or water pollution, the regulatory authority shall limit the size of the area from which topsoil may be removed at any one time and specify methods of treatment to control erosion of exposed overburden.
 - (2) All of the A horizon of the topsoil as identified by soil surveys shall be removed according to paragraph (a) and then

Topsoiling and Bituminous Coal Mining

replaced on disturbed areas as the surface soil layers. Where the A horizon is less than 6 inches, a 6-inch layer that includes the A horizon and the unconsolidated material immediately below the A horizon (or all unconsolidated material if the total available is less than 6 inches) shall be removed and the mixture segregated and replaced as the surface soil layer.

- (3) Where necessary to obtain soil productivity consistent with postmining land use, the regulatory authority may require that the B horizon or portions of the C horizon or other underlying layers demonstrated to have comparable quality for root development be segregated and replaced as subsoil.
- (4) Selected overburden materials may be used instead of, or as a supplement to, topsoil where the resulting soil medium is equal to or more suitable for vegetation, and if all the following requirements are met:

- (i) The permittee demonstrates that the selected overburden materials or an overburden-topsoil mixture is more suitable for restoring land capability and productivity by the results of chemical and physical analyses. These analyses shall include determinations of pH, percent organic material, nitrogen, phosphorus, potassium, texture class, and water-holding capacity, and such other analyses as required by the regulatory authority. The regulatory authority also may require that results of field-site trials or greenhouse tests be used to demonstrate the feasibility of using such overburden materials.
- (ii) The chemical and physical analyses and the results of field-site trials and greenhouse tests are accompanied by a certification from a qualified soil scientist or agronomist.
- (iii) The alternative material is removed, segregated, and replaced in conformance with this section.

(b) TOPSOIL REDISTRIBUTION.

- (1) After final grading and before the topsoil is replaced, regraded land shall be scarified or otherwise treated to eliminate slippage surfaces and to promote root penetration.
- (2) Topsoil shall be redistributed in a manner that--

- (i) Achieves an approximate uniform thickness consistent with the postmining land uses;
- (ii) Prevents excess compaction of the spoil and topsoil; and
- (iii) Protects the topsoil from wind and water erosion before it is seeded and planted.

- (c) TOPSOIL STORAGE. If the permit allows storage of topsoil, the stockpiled topsoil shall be placed on a stable area within the permit area where it will not be disturbed or be exposed to excessive water, wind erosion, or contaminants which lessen its capability to support vegetation before it can be redistributed on

terrain graded to final contour. Stockpiles shall be selectively placed and protected from wind and water erosion, unnecessary compaction, and contamination by undesirable materials either by a vegetative cover as defined in *715.20 (g) or by other methods demonstrated to provide equal protection such as snow fences, chemical binders, and mulching. Unless approved by the regulatory authority, stockpiled topsoil shall not be moved until required for redistribution on a disturbed area.

- (d) NUTRIENTS AND SOIL AMENDMENTS. Nutrients and soil amendments in the amounts and analyses as determined by soil tests shall be applied to the surface soil layer so that it will support the postmining requirements of *715.13 and the revegetation requirements of *715.20.

APPENDIX B
PASME DATA--ALABAMA EXAMPLE

T = 2 FEET

T = 3 FEET

<u>H</u>	<u>TST</u>	<u>PC</u>	<u>H</u>	<u>TST</u>	<u>PC</u>
10	0	4.74	10	0	4.07
20	0	6.31	20	0	5.11
30	0	7.87	30	0	6.16
40	0	9.59	40	0	7.20
50	0	11.15	50	0	8.25
60	0	13.29	60	0	9.44
70	0	14.96	70	0	10.48
80	0	16.63	80	0	11.53
90	0	18.33	90	0	13.13
100	0	20.04	100	0	14.24
110	0	21.74	110	0	15.35
120	0	23.44	120	0	16.47
130	0	25.15	130	0	17.60
140	0	26.85	140	0	18.74
10	2	6.32	10	2	5.12
20	2	7.88	20	2	6.17
30	2	9.45	30	2	7.21
40	2	11.17	40	2	8.25
50	2	12.73	50	2	9.30
60	2	14.30	60	2	10.49
70	2	15.86	70	2	11.54
80	2	17.43	80	2	12.58
90	2	19.86	90	2	13.62
100	2	21.56	100	2	14.67
110	2	23.27	110	2	15.71
120	2	24.97	120	2	17.48
130	2	26.67	130	2	18.62
140	2	28.38	140	2	19.76
10	4	7.90	10	4	6.17
20	4	9.46	20	4	7.22
30	4	11.03	30	4	8.26

Topsoiling and Bituminous Coal Mining

<u>H</u>	<u>TST</u>	<u>PC</u>	<u>H</u>	<u>TST</u>	<u>PC</u>
40	4	12.74	40	4	9.31
50	4	14.31	50	4	10.35
60	4	15.88	60	4	11.54
70	4	17.44	70	4	12.59
80	4	19.01	80	4	13.63
90	4	20.62	90	4	14.68
100	4	22.22	100	4	15.72
110	4	23.82	110	4	16.76
120	4	25.43	120	4	17.81
130	4	28.20	130	4	18.88
140	4	29.90	140	4	19.95

H = 80

H = 100

<u>TST</u>	<u>T</u>	<u>PC</u>	<u>TST</u>	<u>T</u>	<u>PC</u>
0	2	16.6451	0	2	20.0424
1	2	17.3980	1	2	20.8054
2	2	17.4395	2	2	21.5683
3	2	18.2285	3	2	21.4365
4	2	19.0174	4	2	22.2254
5	2	19.8063	5	2	23.0144
6	2	20.5953	6	2	23.8033
7	2	21.3842	7	2	24.5923
8	2	22.1731	8	2	25.3812
9	2	22.9621	9	2	26.1701
0	4	9.3724	0	4	10.9386
1	4	9.7920	1	4	11.3581
2	4	10.1614	2	4	11.7275
3	4	10.5559	3	4	12.1220
4	4	10.9503	4	4	12.5164
5	4	11.3448	5	4	12.9109
6	4	11.7393	6	4	13.3054
7	4	12.1337	7	4	13.6998
8	4	12.5282	8	4	14.0943
9	4	12.9227	9	4	14.4888

THE PHYSIOCHEMICAL LIMNOLOGY OF A TEMPORARY POND
IN NORTH ALABAMA¹

Richard F. Modlin
Department of Biology
The University of Alabama in Huntsville
Huntsville, AL 35807

Abstract. S & J Temporary Pond occupies a 0.2 ha forested depression in Huntsville, Alabama and usually contains water from December to June. Its existence is strongly dependent on the magnitudes of rainfall and evapotranspiration. The dynamics of nitrite and phosphate are regulated by ecological events that occur in the watershed, while ammonia and nitrate are controlled by the biology of the pond. A single species of benthic algae is the primary producer. Consumer organisms are predominantly zooplanktonic. Metabolically the pond is a heterotrophic rather than an autotrophic system.

INTRODUCTION

In previous studies the physiochemical aspects of temporary ponds were presented primarily to describe and characterize the habitats of organisms that live in these ephemeral aquatic systems (Dickinson 1948, Kenk 1949, Rzoska 1961, Moore 1970, Daborn and Clifford 1974). Cole and Fisher (1978) examined temporary pond metabolism. Felton et al. (1967) studied the role bacteria play in nutrient cycling within a temporary pond system. Data from these studies suggest that temporary ponds have two common features. (1) The major chemical and physical processes in the ponds are very sensitive to climatic conditions (Rzoska 1961, Sublette and Sublette 1967, Moore 1970, Daborn and Clifford 1974); and (2) the ponds are dominated by the biology and chemistry of the watershed in which they are situated (Moore 1970, Daborn and Clifford 1974). All the above indicate that temporary ponds vary limnologically with latitude, altitude and the composition of watershed. The objective of this research was to report the physiochemical condition of a temporary pond (S & J Pond) located in northern Alabama.

Description of the Study Area

S & J Pond occupied a shallow forested depression located 200 m northwest of the junction of Sparkman Drive and Jordan Lane in northwest Huntsville, Madison County, Alabama (T3S R1W Sec. 28). The pond, when it was filled to maximum water volume (513 m³), was almost rectangular

¹Manuscript received 2 October 1979; accepted 21 February 1980.

Physiochemical Limnology of a Temporary Pond

in shape with a surface area of 2125 m². It has a mean depth of 0.25 m and a maximum depth of 0.81 m. There were no surface inlets or outlets to the pond and general runoff was negligible. Water primarily from subsurface seepage filled the depression. However, if the pond exceeded its maximum size the excess water spilled over an embankment into a roadside drainage ditch.

The watershed was about 1.6 km² and within the immediate vicinity of the pond it was forested. North and west of the pond the watershed was composed of agricultural fields. It was delineated to the east and south by roadways. The pond was located in the southeastern corner of the watershed.

Sweetgum trees, *Liquidambar styraciflua*, in almost a pure stand and an occasional willow, *Salix* sp., completely canopied the study site from April to November. During the growing season the depression was nearly devoid of forest floor vegetation. Sparse clumps of grasses grew in spaces within the depression that received direct sunlight. The honeysuckle vine, *Lonicera* sp., dominated the forest perimeter.

Surface soil in and around the depression was composed of Abernathy Silt Loam. This soil was slightly acidic, rich in nutrients and had a strong ability to hold moisture (Swenson et al. 1958). It was covered with 0.5-2.0 cm of leaf litter.

METHODS

Chemical parameters were measured biweekly and physical parameters were measured weekly from December, 1977 to June, 1978, the period of time the pond contained water. Duplicate water samples were collected near the middle of the pond. One liter acid washed bottles were submerged to a depth of 0.5 m, uncapped, allowed to fill, and then recapped. Standard BOD bottles, filled as above, were used to collect water for dissolved oxygen and free CO₂ determinations. Because of the air initially present in the BOD bottles, the bottle submergence method of water collecting may cause an error in the actual concentrations of gases present in the sample. However, the magnitude of this error is slight, about a 1% increase in D.O. at a low pO₂ in the water, and not significantly different (at 1% level) than if the bottles were filled directly from a VanDorn or Kemmer water sampler (Modlin unpublished data). A one-way ANOVA (Snedecor and Cochran 1967) was used to compare the changes in D.O. that occurred between BOD bottles filled by submergence and those filled by standard methods from water samplers. The D.O. values used to calculate pond metabolism were corrected for this error. Conductivity and temperature were measured in the field with a YSI Model 33 SCT Meter and pH was measured with a Sargent-Welch Field pH Meter. Dissolved oxygen, free CO₂ and alkalinity were determined by standard methods immediately upon return to the laboratory (American Public Health Association 1971). The laboratory was 2 km from the study site. Hach spectrophotometric water analysis procedures were used to determine the concentrations of ammonia, nitrate, nitrite, soluble phosphate, total iron, and tannins and lignins (Hach Chemical Company 1973). Water samples were filtered prior to each test. Standard solutions were used to calibrate the Hach DR/2 Spectrophotometer.

Metabolism of the pond was measured in January, March, April and May. A modified diurnal oxygen curve (Welch 1968) was used to determine whole system metabolism and the light-dark bottle technique estimated the phytoplankton contribution (American Public Health Association 1971). The D.O. values obtained during the metabolism studies were converted to carbon units with the conversion factor $0.375 \text{ mg O}_2 = 1.0 \text{ mg C}$ (Lind 1974), which is equivalent to 9.4 cal (Brylinsky and Mann 1973).

A measuring tape was used to measure the total length and average width of the pond on three occasions; when it was full, half full and two weeks before it dried. A stationary pole placed near the center of the pond was used to measure depth. The pole was marked, when first put into position, with the height of the pond surface at that time. Weekly changes in depth were noted by the distance the pond surface fluctuated above and below this initial mark. Changes in surface area of the pond were estimated from the length of a level line drawn taut from the pole to the shore. Additional depth measures were made with a meter stick. Water volume was calculated according to Wetzel (1975).

Benthic and zooplanktonic samples were collected weekly. Zooplankton samples were taken in triplicate. A wide mouth 1.2 l jar was held on the bottom of the pond for one minute to allow the water column above the jar to stabilize. It was then uncapped, filled and recapped. The benthos was sampled with a D-ring dip net pushed along the bottom. All samples were fixed in 5% formalin, sorted into taxonomic groups, counted and, if possible, identified to the species level.

Daily meteorological data were obtained for the years 1977 through 1979 from the NOAA Environmental Data and Information Service located at the Madison County Jetplex which is about 25 km southwest of the study site.

Dates the pond filled and dried during the 1978-79 season were noted.

RESULTS

Sufficient water, from the heavy rainfalls in November (29.3 cm), had accumulated to fill the pond during the week of 12 December 1977 (Fig. 1). From December to the end of March water volume fluctuated about a mean of 441 m^3 . Although rainfall in the spring was higher than in the winter, water volume decreased very rapidly during the first two weeks of April (Fig. 1). Surface to volume ratios changed from 4.2 in winter to 6.7 in spring. The temporary pond dried completely during the week of 19 June 1978. It contained water for 195 days.

The temperature of the temporary pond water was influenced by the air temperature (Fig. 2). However, while air temperature fluctuated drastically in winter, fluctuations in water temperature were moderate. The lowest water temperature recorded was 4°C . During the last week in January and the first week in February a 3 cm layer of ice covered the pond. Under the ice, the water was inversely stratified. Water temperature was 0°C just under the ice, but it rapidly increased to 4°C three

Physiochemical Limnology of a Temporary Pond

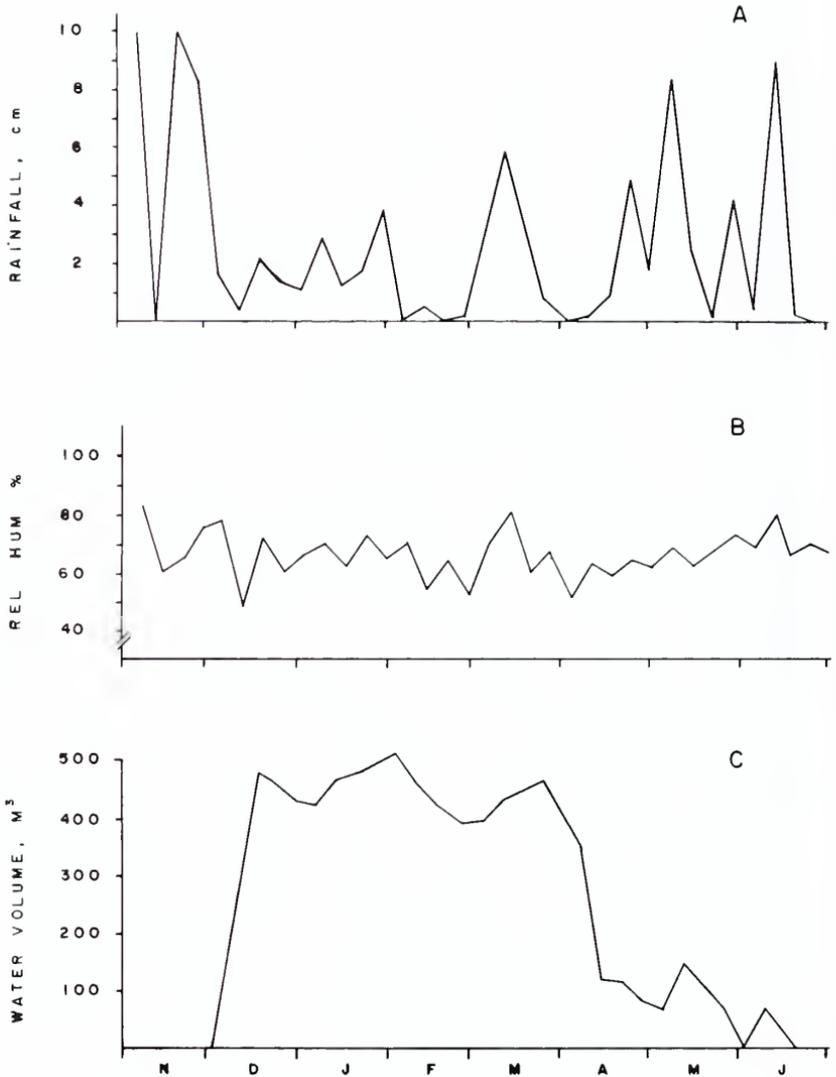


Figure 1. Rainfall (A) and relative humidity (B) recorded in Huntsville, Alabama, during the study period, November 1977 to June 1978 and the changes in the volume of water (C) in S & J Pond.

centimeters below the ice. This was the only time the pond thermally stratified. During the first 10 days of March water temperature increased from an average of 7.2°C to an average of 18°C (Fig. 2).

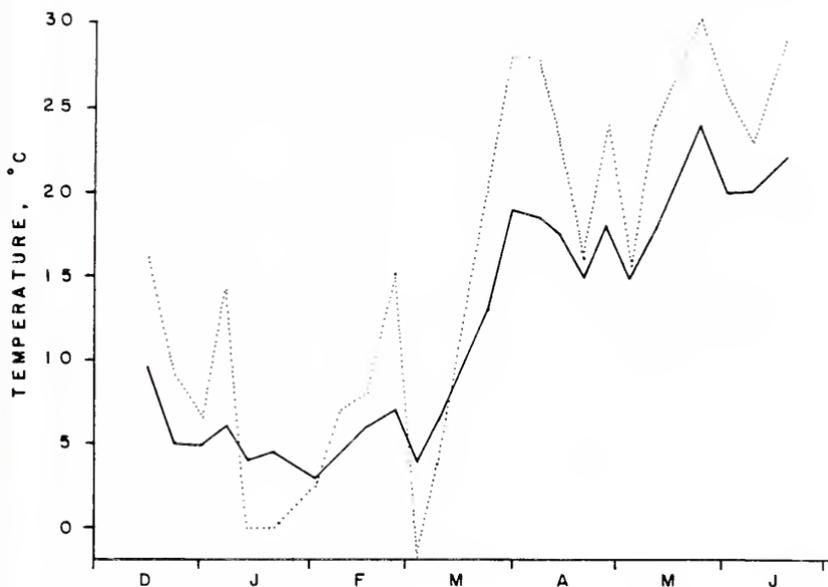


Figure 2. Air temperature (dotted line) and water temperature (solid line) recorded at S & J Pond, Alabama, during the study period, December 1977 to June 1978.

Changes in the concentrations of D.O. and free CO_2 followed similar patterns. Dissolved O_2 increased from less than 1.0 mg/l to 3.8 mg/l three days after the pond filled. It reached a maximum daytime concentration of 6.2 mg/l at the end of February. Thereafter, D.O. continually decreased. Maximum daytime concentration was about 0.5 mg/l in mid-May. During peak primary production the average maximum-minimum diurnal change was about 3.0 mg/l.

Carbon dioxide concentration was about 4.0 mg/l when the pond filled. It reached a maximum amount of 57.7 mg/l near the end of April. However, unlike the D.O., concentrations of free CO_2 decreased only slightly as the pond tended toward extinction. Average free CO_2 during the life of the pond was 26.7 mg/l (Table 1). March maximum-minimum diurnal change was about 5.0 mg/l.

The water in the pond was soft and acidic. The pH oscillated from 5.0 to 6.8 and averaged 6.2 (Table 1). Alkalinity and conductivity averaged 2.20 mg/l as CaCO_3 and 22.2 μMhos at 25°C, respectively (Table 1).

Physiochemical Limnology of a Temporary Pond

TABLE 1. Maximum, minimum and mean concentrations of the chemical parameters measured in S & J Pond, Alabama, from December 1977 to June 1978.

Parameter	Maximum	Minimum	Mean	Units
Dissolved O ₂	6.2	0.5	2.8	mg/l
Free CO ₂	57.7	4.4	26.7	mg/l
Alkalinity as CaCO ₃	2.90	1.67	2.20	mg/l
pH	6.8	5.0	6.2	
NH ₃	0.84	0.0	0.30	mg/l
NO ₂ ⁻	0.004	0.0	0.003	mg/l
NO ₃ ⁻	9.0	3.6	5.6	mg/l
Soluble PO ₃ ⁻	0.48	0.06	0.16	mg/l
SO ₄ ⁻²	5.0	2.0	3.6	mg/l
Total Fe	0.14	0.04	0.08	mg/l
Lignins & Tannins	0.71	0.20	0.46	mg/l
Conductivity	30.0	18.0	22.2	μMhos @ 25°C

Nutrients, NH₃, NO₂⁻, NO₃⁻ and PO₄⁻³, varied considerably with time. Ammonia and NO₃⁻ increased while the pond aged, but NO₂⁻ decreased (Fig. 3). Soluble PO₄⁻³ increased slightly with time, but a major peak in concentration, 0.48 mg/l, occurred during the first week of March (Fig. 4).

Results of the diurnal oxygen determinations indicated that primary production exceeded respiration during the first four months of the pond's existence. Maximum values were reached in March and April (Table 2). The pond was fully exposed to solar radiation from the time it filled until April. Although gross production declined in early April, net production remained the same as in March (Table 2). However, in April the trees began to leaf. They were in full foliage by the end of the month and the pond was shaded. This resulted in a large deficit in net production and a P/R ratio equal to 0.4 (Table 2). Production in the pond switched from autotrophic to heterotrophic. An average P/R value suggested that on the whole the temporary pond was a heterotrophic system (Table 2).

Primary production was chiefly due to a single benthic alga, *Draparnaldia glomerata*. It was present from late February until early May. During March this alga covered all submerged substrates. Phytoplankton was almost non-existent. Detectable results in the light-dark bottle analyses were obtained only in March and April, 0.09 and 0.2 mg C/l/day gross production, respectively.

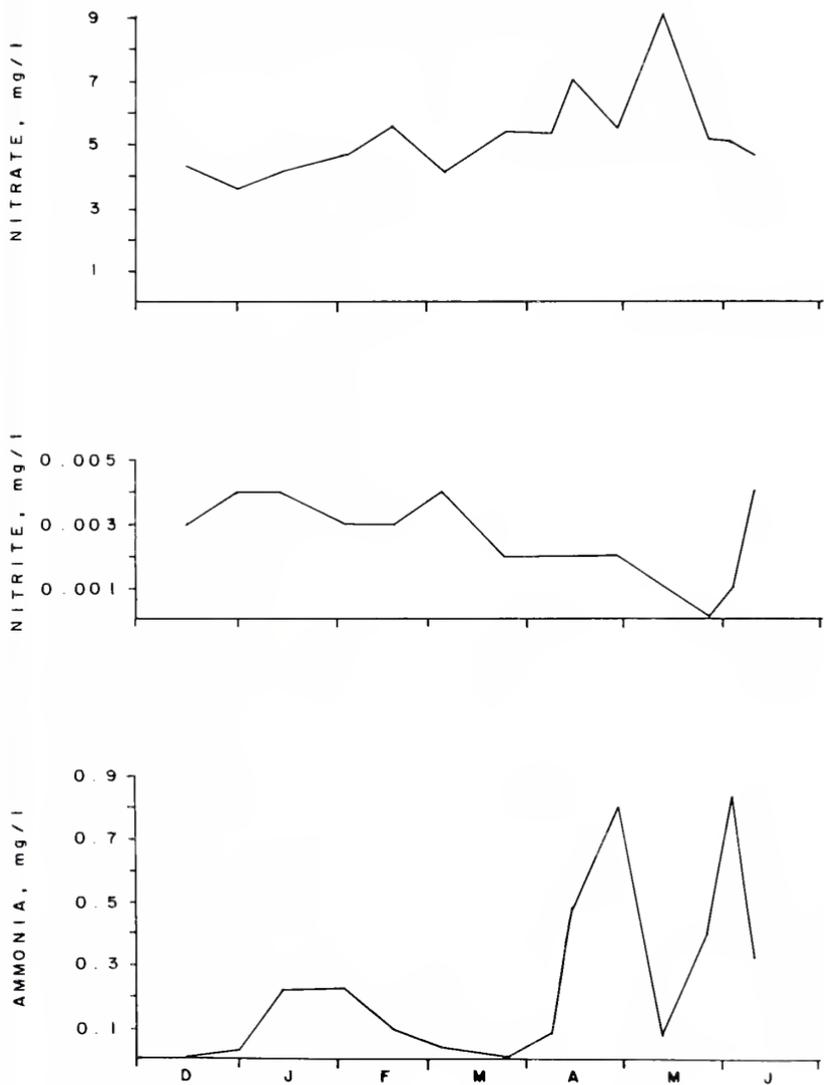


Figure 3. Changes in nitrate, nitrite and ammonia concentrations recorded in S & J Pond, Alabama, during the period of study, December 1977 to June 1978.

Physiochemical Limnology of a Temporary Pond

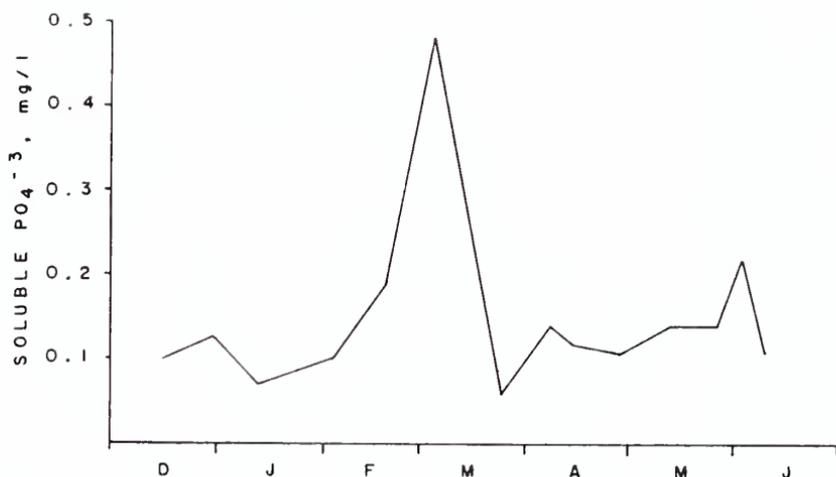


Figure 4. Change in the phosphate concentration recorded in S & J Pond, Alabama, from December 1977 to June 1978.

TABLE 2. Whole system metabolism as kcal/m²·day produced and respired in S & J Pond, Alabama, as determined from diurnal oxygen curves.

Date	P/R	Production		Respiration
		Gross	Net	
1/ 6/78	1.0	11.90	0.56	10.62
3/24/78	1.4	13.91	4.23	9.78
4/ 7/78	2.4	7.05	4.14	2.91
5/12/78	0.4	22.37	-36.10	57.72
Average	0.6	13.72	- 6.86	20.30

Zooplanktonic crustaceans were the dominant organisms in the pond. Their numbers remained low during the winter months, about 50 individuals/l. In early spring they increased to an average of 300/l. However, two weeks before the pond dried zooplankton numbers increased rapidly to over 3000/l. Dominant species were in the Cladocera, *Daphnia pulex* and *Ceriodaphnia laticaudata*, and Copepoda, *Diaptomus stagnalis* and *D. sanguineus*. No anostracans were collected during the study year. However, during the 1978-79 year *Eubranchipus vernalis* was the chief constituent

of the zooplankton. The benthos was composed of the amphipod *Crangonyx floridanus*. In the spring, juvenile crayfish, corixid adults and chironomid larvae became numerous. The crustacean groups will be treated more comprehensively in subsequent papers.

DISCUSSION

Environmental factors that contribute to the flooding of a temporary pond basin are precipitation, evaporation and soil moisture (Moore 1970). Of primary importance, is the amount of precipitation that falls during a limited time interval (Moore 1970). Although 29.3 cm of rain was recorded in November of the study year, the important condition, that allowed the pond to fill in December, was that the major portion of this rain fell during two separate one week periods (Fig. 1). In both weeks the amount was about 8 cm. Water did not accumulate during the 1978-79 year until January 1979 because sufficient rain did not occur until December 1978. Precipitation in December 1978 amounted to only 9 cm, but 5.8 cm fell in a single week (Modlin, unpublished data). Moore (1970) found that 5-8 cm of precipitation in a single week was required to fill basins in Louisiana.

Evapotranspiration strongly affects the hydrodynamics of temporary ponds. Although the conditions of rainfall were met in March, April and May (Fig. 1), and many other times during the summer, the pond dried and did not refill until mid-winter. Most vegetation becomes dormant in northern Alabama by mid-November. Evapotranspirative processes are reduced to their minimum. If the other conditions are met, the pond will fill and remain filled until foliation reoccurs. Deciduous trees begin to foliate in early April and most are maximally leaved by the end of April. Within 10 days during this month the pond lost 72% of its water volume (Fig. 1). Prior to April the average loss was less than 4%. Relative humidity changed little, but the rise in temperature in March increased the evaporative processes (Hutchinson 1957). Nevertheless, the increase in evaporation was not great enough to account for the considerable loss of water in such a short period of time. Sixty to seventy percent of this loss was attributed to evapotranspiration (Holdredge 1967, Dohrenwend 1977).

Dynamics of the nutrient compounds in the pond are primarily regulated by the chemical composition and the events that occur in the watershed. Nitrite oxidizing bacteria are only found in the soils outside the boundaries of the temporary ponds (Feldon et al. 1967). The two peaks in NO_2^- concentration (Fig. 3) are attributed to groundwater inflow. In early January NO_2^- was brought into the pond by the initial flood water. The high concentration in early March is attributed to inflow of water after the watershed thawed. Likewise soluble PO_4^{3-} is also brought into the pond by groundwater (Fig. 4), only the results are more dramatic. The watershed was intensively used for agricultural purposes and the fields were fertilized. Utilization of the fertilizers was reduced during the winter, especially when the soil was frozen. While the surface soil is frozen various physical processes lead to the release and accumulation of soluble PO_4^{3-} (Campbell et al. 1970, Hinman 1970). Therefore, when the watershed thaws and the surface water percolates through the

Physiochemical Limnology of a Temporary Pond

soil and eventually seeps into the temporary pond, it is highly enriched with phosphate. Daborn and Clifford (1974) recorded a high influx in phosphate into temporary ponds in Canada after the soil water melted. Meltwater contributes phosphates to some permanent bodies of water (Hutchinson 1957).

The high concentration of soluble PO_4^{-3} stimulated *Draparnaldia glomerata* to bloom in March. Upon the onset of the algal growth, soluble PO_4^{-3} was rapidly reduced to its lowest value, 0.06 mg/l. However, within a short period of time its concentration returned to the average level of 0.12 mg/l (Fig. 4). The spring influx of soluble PO_4^{-3} had a similar effect in other temporary ponds (Moore 1970, Daborn and Clifford 1974). The slight increase in June (Fig. 4) was due to rapid degradation of organic material stimulated by higher water temperatures (Fig. 2) (Hutchinson 1957).

Concentrations of NH_3 and NO_3^- were influenced by the biology in the pond. Fluctuations in NH_3 (Fig. 3) coincided with the oscillations in the cladoceran populations. Although the species composition varied, the numbers of Cladocera peaked in January, April and June (Modlin, unpublished data). The NO_3^- pulses, which occurred slightly after the NH_3 peaks, and the general increase in NO_3^- concentration (Fig. 3) indicated bacterial oxidation of the NH_3 in addition to its input from the watershed. High numbers of NH_3 oxidizing bacteria were found in the soils of even slightly acidic temporary pond basins (Feldon et al. 1967).

Production and respiration values estimated for S & J Pond were comparative with those calculated for other temporary ponds. Average annual gross whole system production and respiration was 2675 kcal/m²·yr and 3959 kcal/m²·yr, respectively (Table 2). Cole and Fisher (1978) found whole system production and respiration in Lost Pond, Massachusetts, was 2140 kcal/m²·yr and 2669 kcal/m²·yr, respectively. Lost Pond is situated on the slope of a mountain and has a smaller watershed than S & J Pond. Therefore, the slightly lower values in production and respiration in Lost Pond can be explained by the difference in nutrient content of the two ponds. Soluble PO_4^{-3} and NO_3^- levels in Lost Pond were both less than 0.01 mg/l (Cole and Fisher, 1978), while in S & J Pond both nutrient anions were of higher concentrations (Table 1). Both ponds contained about the same amount of water.

Benthos dominated production and respiration in S & J Pond as it did in other temporary ponds (Moore 1970, Cole and Fisher 1978). Phytoplankton played a minor role. When detectable, it accounted for less than 10% of the primary production.

Although S & J Pond was autotrophic during part of its existence, an average P/R ratio of 0.6 (Table 2) indicates that more energy was used in the pond than was produced. Therefore, the system was heterotrophic. A P/R ratio of 0.8 calculated for Lost Pond shows a similar situation. Moore (1970), except in rare cases, also found that temporary ponds are heterotrophic systems. The additional energy is derived from allochthonous material primarily in the form of leaf litter (Moore 1970). Felton et al. (1967) found the water and sediments of temporary ponds

rich in aerobic and anaerobic heterotrophic bacteria and cellulose decomposers.

ACKNOWLEDGEMENTS

I would like to thank Pamela S. Modlin for her assistance in collecting and analyzing the water samples.

LITERATURE CITED

- American Public Health Association. 1971. Standard Methods for the Examination of Water and Waste Water, 3rd Edition. American Public Health Association, 874 p.
- Brylinsky, M. and K. H. Mann. 1973. An analysis of factors governing productivity in lakes and reservoirs. *Limnology & Oceanography*, 18:1-14.
- Campbell, C. A., W. S. Ferguson and F. G. Warder. 1970. Winter changes in soil nitrate and exchangeable ammonium. *Canadian Journal of Soil Science*, 50:151-162.
- Cole, J. and S. G. Fisher. 1978. Annual metabolism of a temporary pond ecosystem. *The American Midland Naturalist*, 100:15-22.
- Daborn, G. R. and H. F. Clifford. 1974. Physical and chemical features of an aestival pond in western Canada. *Hydrobiologia*, 44:43-59.
- Dickinson, J. C. 1948. An ecological reconnaissance of the biota of some ponds and ditches in northern Florida. *Quarterly Journal of the Florida Academy of Science*, 11:1-28.
- Dohrenwend, R. E. 1977. Evapotranspiration patterns in Florida. *Florida Scientist*, 40:184-192.
- Felton, M., J. J. Colney and W. G. Moore. 1967. A quantitative study of the bacteria of a temporary pond. *Journal of General Microbiology*, 47:25-31.
- Hach Chemical Company. 1973. *Water Analysis Handbook*. Hach Chemical Company.
- Hinman, W. C. 1970. Effects of freezing and thawing on some chemical properties of three soils. *Canadian Journal of Soil Science*, 50: 179-182.
- Holdridge, L. R. 1967. *Life Zone Ecology*. Tropical Science Center, San Jose, Costa Rica.
- Hutchinson, G. E. 1957. *A Treatise on Limnology, Volume 1*. John Wiley & Sons, New York, 1015 p.

Physiochemical Limnology of a Temporary Pond

- Kenk, R. 1949. The animal life of temporary and permanent ponds in southern Michigan. University of Michigan Miscellaneous Publication, 71:1-66.
- Lind, O. T. 1974. Handbook of Common Methods in Limnology. The C. V. Mosby Co., St. Louis, Mo., 154 p.
- Moore, W. G. 1970. Limnological studies of temporary ponds in southeastern Louisiana. The Southwestern Naturalist, 15:83-110.
- Rzoska, J. 1961. Observations on tropical rainpools and general remarks on temporary waters. Hydrobiologia, 17:265-286.
- Snedecor, G. W. and W. G. Cochran. 1967. Statistical Methods, 6th Edition. The Iowa State University Press, Ames, Iowa, 593 p.
- Sublette, J. E. and M. Sublette. 1967. The limnology of playa lakes on the Llano Estacado, New Mexico and Texas. The Southwestern Naturalist, 12:369-406.
- Swenson, G. A., H. Sherard, A. Baxter, R. Franham, H. J. Wesson and B. E. Young. 1958. Soil Survey of Madison County, Alabama. U.S. Department of Agriculture, Soil Conservation Service.
- Welch, H. E. 1968. Use of modified diurnal curves for the measurement of metabolism in standing water. Limnology & Oceanography, 13: 679-687.
- Wetzel, R. 1975. Limnology. W. B. Saunders Co., Philadelphia, 743 p.

INFORMATION NEEDS AND SOURCES OF ALABAMA FARMERS¹

James L. Stallings and George L. Harrison

*Department of Agricultural Economics and Rural Sociology
Auburn University
Auburn, AL 36830*

INTRODUCTION

A number of people and organizations in Alabama are interested in kinds of information farmers need for operating their farm business and where they get that information. Among different government agencies interested in this type of information is the Cooperative Extension Service, a direct link between the farmer and various sources of information. The Extension Service must constantly plan programs to inform farmers and be ready to answer farmers' questions on a wide variety of subjects. Also providing information for the Extension Service and for farmers and others directly is the State Agricultural Experiment Station system. Much of the research carried on at these stations is based on an assessment of farmers' needs for information. The various State organizations such as the Alabama Department of Agriculture and Industries and the Alabama Crop and Livestock Reporting Service are interested in this kind of information in order to plan their programs and data needs. Farmer organizations, both general and commodity oriented, are vitally interested in the kinds of information needed by farmers and their various sources. Obviously, the newspaper, magazine, radio, and television media are interested in this type of information. More particularly, advertisers of different products used by farmers want to know through which media they can best get their message across.

A review of previous research on this subject for Alabama revealed no applicable previous work which could adequately answer the questions asked by various people as to what kinds of information farmers need and where they get it. The study reported in this article was designed to answer some of these questions for Alabama. The specific objectives were:

1. To determine for Alabama farmers *kinds* of information needed by:
 - a. All farmers,
 - b. Different commodity groups, and
 - c. Different income levels.
2. To determine for Alabama farmers *sources* of information used by:
 - a. All farmers,
 - b. Frequency of use,

¹Manuscript received 13 September 1979; accepted 25 February 1980.

Information Needs and Sources of Alabama Farmers

- c. Kind of information needed,
- d. Commodity groups,
- e. Gross farm income levels,
- f. Years of formal education, and
- g. Age of operator.

PROCEDURE

A mail questionnaire was designed and sent to a sample of 1,335 farmers in Alabama in April 1977. Farmers were asked to give answers for calendar year 1976. A stratified random sample was drawn by eight important commodity groups: beef, corn, poultry, soybeans, pork, dairy, peanuts, and cotton. The sample was chosen in this way, with advice and help of the State Statistician of the Alabama Crop and Livestock Reporting Service, in order to ensure an adequate number of replies from each commodity group so that differences in kinds of information needed and sources used by these groups could be determined. If a completely random sample had been taken of all farmers in Alabama, regardless of commodity affiliation, the sample would have had to be unreasonably large and expensive in order to assure adequate numbers in each commodity group. Questionnaires returned with the initial mailing, plus one follow up letter one week later, were as follows:

	<u>No.</u>	<u>Pct.</u>
Returned complete and usable	338	25.3
Returned partially completed and usable	42	3.1
Returned but not usable	10	.7
Returned but no longer farming	29	2.2
Returned, not deliverable	17	1.3
Total returned	436	32.7
Total sent	1,335	100.0

It was thought desirable to compare the characteristics of the sample with the characteristics of the whole State in order to test its validity in inference for all farmers as the sample was stratified by eight commodity groups and not randomized for all farmers. As the Alabama Crop and Livestock Reporting Services does not publish much of its information on number of farms by the same characteristics as in the sample, it was necessary to make comparisons with the 1974 Census of Agriculture. Characteristics of the sample, with 1974 Census Comparisons, when available, are as follows:

<u>Commodity Group</u>	<u>1976 Sample</u>		<u>1974 Census</u>	
	<u>No.</u>	<u>Pct.</u>	<u>No.</u>	<u>Pct.</u>
Beef Cows	231	61	31,015	55
Corn	191	50	22,457	40
Soybeans	100	26	8,555	15
Laying Hens	64	17	7,216	13
Cotton	25	7	6,827	12
Milk Cows	70	18	6,120	11
Peanuts	64	17	4,369	8
Broilers	65	17	3,382	6
Feeber Pigs Sold	26	7	2,720	5
Numbers	<u>380</u>		<u>56,678</u>	

While a comparison with the 1974 Census 2 years earlier than the sample year is not an ideal comparison, the results indicate little problem in inference to the total population for the two most numerous commodity groups (beef cows and corn), as the percentages here are reasonably close. Soybeans represent a larger percent in the 1976 sample than in the 1974 Census but this may be due to actual increases in acreages since 1974. The cotton farmers in the sample were fewer than desired, probably because the questionnaire came at a time when they were planting. The milk cows, peanuts, and broilers categories, however, were purposely chosen to represent a larger percent of the sample than for the State in order to get an adequate number for analysis. Considering that the more numerous commodity groups, beef and corn, are reasonably close, and that the rest of the commodity groups are, to a large extent, grown on farms containing these two commodities, it is felt that inferences to the total population may be good and not be unduly biased.

KINDS OF INFORMATION NEEDED BY ALABAMA FARMERS

There are two aspects of determining information needs of Alabama farmers, kinds of information needed and where this information is obtained. This section deals with the kinds of information needed while the following section deals with sources.

Needs of All Farmers

Important kinds of information needed by farmers in general, regardless of commodity group, income level, age, education or other variables, are presented in Table 1. The 23 kinds of information presented in the table are not all of the many kinds of information needed by farmers, but represent those reported as needed by more than 10 percent of the farmers responding.

Livestock prices, either historic, present, or future, are the single most important kind of information reported as needed by Alabama farmers.¹ This is not surprising when it is considered that well over half of Alabama farmers have beef cattle; and, by including other classes of livestock, an even higher percentage of Alabama farmers is accounted for.

Ranking second and third was kind and amount of fertilizer to use. Not far down in rank also, and in the top 10, were kinds and amount of insecticides and herbicides to use. Together, fertilizers, insecticides, and herbicides were a class of inputs very much on the mind of Alabama farmers and represent an important concern of modern agriculture.

Livestock disease information ranked fourth and, again, reflects the importance of livestock in the Alabama agricultural economy.

Another type of information ranking in the top 10 concerns of Alabama farmers was grain prices. This also reflects the importance of

¹Throughout this article, the information category "prices" is a general concept including historic, present, and future prices.

Information Needs and Sources of Alabama Farmers

TABLE 1

KINDS OF INFORMATION REPORTED NEEDED BY
FARMERS, ALABAMA, 1976

Kinds of Information Reported Needed	Number	Percent
<u>Prices</u>		
Livestock Prices	308	81.1
Grain Prices	224	58.9
Soybean Prices	138	36.3
Cotton Prices	73	19.2
<u>Cultural Practices</u>		
Which Fertilizer to Use	272	71.6
How Much Fertilizer to Use	259	68.2
Which Insecticide to Use	226	59.5
How to Apply Insecticides	208	54.7
Which Herbicide to Use	202	53.2
How to Apply Herbicides	188	49.5
<u>Innovations</u>		
New Farm Practices	183	48.2
New Crop Varieties	151	39.7
New Crop or Livestock Enterprise for the Farm	149	39.2
New or Different Livestock Breeds	144	37.9
<u>Federal Information</u>		
Federal Government Programs for Farms	174	45.8
Federal Government Regulations for Farms	150	39.5
Federal Income Tax Problems	130	34.2
<u>Machinery Information</u>		
What Type of Farm Machinery to Buy	167	43.9
Farm Machinery Repair Methods	151	39.7
<u>Other Information</u>		
Livestock Disease Information	238	62.6
Expected Yields for Crops	129	33.9
Hedging Crops and Livestock	79	20.8
Farm Leasing and Tenure Arrangements	69	18.2

livestock, because grain is an input to the livestock industry. Grain prices, along with soybeans and cotton prices, are a very important class of information needed by Alabama farmers.

New farm practices complete the top 10 concerns of Alabama farmers. This, along with new crop varieties, new crop or livestock enterprises for the farm, and new or different livestock breeds, are similar types

of concerns of Alabama farmers representing an important class of information needed.

Needs of Farmers by Commodity Groups

Livestock prices ranked as the number one kind of information needed by Alabama farmers for all commodity groups except one, as they did for all farmers. Over 90 percent of the pork producers and 88 percent of the beef producers reported a need for this kind of information. Only cotton producers ranked fertilizer use as their number one concern.

Ranking second and third for most commodity groups, however, was kind and amount of fertilizer to use. This is probably because most farmers in livestock groups also have crops and were, generally, equally concerned with this kind of information. There were some differences in the peanut, and cotton groups, however. For these groups, insecticides ranked higher than fertilizers, reflecting the extreme importance of insecticide inputs for these commodity groups.

Grain prices ranked third and fourth with soybeans, pork, and dairy groups, while livestock disease information ranked fourth with the beef, poultry and cotton groups. The latter might be considered a surprise except an examination of the data revealed that most cotton farmers also had livestock.

Needs of Farmers by Gross Farm Income Levels

It was expected that high and low income farmers would have need for different kinds of information; and, that high income farmers, in general, would perceive a need for all kinds of information more than low income farmers. Data generally bear out these hypotheses.

While it was generally true that the percent of farmers reporting a need for different kinds of information went up as income increased, there was a downturn in the percentage after a certain high income, generally the \$40,000-99,999 level.

For some kinds of information, the relationship between expressed need and income level was greater than others. The strongest relationships were for information on hedging and soybean prices. This is probably because only farmers with large volumes of products would be interested in hedging and these are the large farmers with high farm incomes. Perhaps less clear is why there is such a strong relationship for soybean prices. The best explanation from the data appears to be that soybeans are generally more often grown on large farms.

Other types of information for which there was an important relationship between expressed need and income were leasing and tenure arrangements, type of machinery to buy, expected yields, new farm practices, new crop varieties, new crop and livestock enterprises, new and different livestock breed, how to apply herbicides, and which herbicides to apply.

Information Needs and Sources of Alabama Farmers

SOURCES OF INFORMATION USED BY ALABAMA FARMERS

While the previous section dealt with the kinds of information needed by Alabama farmers, this section is concerned with where information is obtained. First, information sources are presented for all farmers regardless of any other characteristics. Then comparisons are made concerning: frequency of use of different sources, sources used for different important kinds of information, sources by different commodity groups, sources by gross farm income levels, sources by age levels, and sources by years of formal education.

Sources for All Farmers

For persons interested in getting information to farmers, the survey indicated that nearly 85 percent of Alabama farmers report farm magazines as a source of at least some information for running their farm business, Table 2. And, for advocates of the "key farmer" approach to extension, the survey further indicated that "other farmers" were a source of information for nearly 78 percent of Alabama farmers. Farm supply stores and cooperatives were another important source for nearly 69 percent of Alabama farmers. Other sources reported by over 50 percent of Alabama farmers, in order, were the County Agricultural Conservation and Stabilization Service Office, the County Extension Office, the Alabama Crop and Livestock Reporting Service, newspapers, radio programs, fertilizer dealers and sales representatives, television, and Experiment Station scientists.

Frequency of Use of Different Sources

In addition to farm magazines being the most often reported source of information, they were also the most frequently used, Table 3. Over 70 percent of Alabama farmers in the survey reported using farm magazines daily to once a month. No other source was even very close to this frequency of use. Newspapers, radio, and television also were used often, with newspapers reported used daily to once a month by 52 percent of the farmers, radio by 47.7 percent, and television by 44.4 percent.

Some sources of information reported used by over 50 percent of Alabama farmers were not used frequently, however, mostly due to the nature of the information. While "other farmers" were reported used by nearly 78 percent of Alabama farmers, only 48 percent of these reported using this source daily to once a month while another 44 percent reported using the source once a month to once a year. The same pattern was true for farm supply stores and cooperatives. It was also true of sources such as the County Agricultural Stabilization and Conservation Service Office, the County Extension Office, fertilizer dealers or sales representatives, Agricultural Experiment Station scientists, Cooperative Extension Service publications, Cooperative Extension Service specialists, the County Soil Conservation Service Office, and similar sources where the type of information obtained tended to be needed less frequently.

TABLE 2

SOURCES OF INFORMATION REPORTED USED BY
ALABAMA FARMERS, 1976

Sources of Information Reported Used	Number	Percent
<u>Print Media</u>		
Farm Magazines	322	85.7
Crop and Livestock Reporting Service	231	60.8
Newspapers	227	59.7
Extension Service Publications	182	47.9
Publications of Farm Organizations	178	46.7
Handbooks	164	43.2
Experiment Station Publications	143	37.6
"Highlights of Agricultural Research"	106	27.9
<u>Electronic Media</u>		
Radio Programs	212	55.8
Television	207	54.5
<u>Personal Sources</u>		
Other Farmers	295	77.6
Farm Supply Stores and Cooperatives	261	68.7
County ASC Office	243	63.9
County Extension Chairman or His Staff	239	62.9
Fertilizer Dealer or Sales Representative	209	55.0
Experiment Station Scientist	198	50.8
Extension Specialist	181	47.6
County SCS Office	171	45.0
Machinery Dealer or Sales Representative	170	44.7
Chemical Company Representative	164	43.2
Field Days, Tours, and Demonstrations	145	38.2
Local Experiment Stations	137	36.1
Vocational Agriculture Teacher	87	22.9
Meetings at Auburn University	49	12.9
Meetings at Alabama A&M University	8	2.1
Meetings at Tuskegee Institute	6	1.6

Sources by Kind of Information

Various persons and groups may be interested in where specific kinds of information are obtained by farmers. For example, a manufacturer or dealer in some product may wish to know whether or not it is advisable to advertise and where. The Cooperative Extension Service wants to know what kinds of information farmers usually obtain from them. The Agricultural Experiment Station system wishes to know where farmers get their ideas about new crop varieties or new or different livestock breeds. For various interests, it was considered useful to analyze the data concerning farmers' sources of information by specific

Information Needs and Sources of Alabama Farmers

TABLE 3
FREQUENCY OF USE OF DIFFERENT INFORMATION SOURCES BY ALABAMA FARMERS, 1976

Rank	Sources of Information	Total Number Reporting Use	Pct. Reporting Different Frequencies		
			Daily to Once a Month	Once a Month to Once a Year	Once a Year or Less
1	Farm Magazines	322	70.5	24.8	4.7
2	Other Farmers	295	48.1	44.4	7.5
3	Farm Supply Stores and Co-ops	261	42.6	49.0	8.4
4	County ASCS Office	243	23.0	51.9	25.1
5	County Extension Office	239	34.3	49.4	16.3
6	Alabama Crop and Livestock Reporting Service	231	46.3	39.8	13.9
7	Newspapers	227	52.0	39.2	8.8
8	Radio	212	47.7	35.8	16.5
9	Fertilizer Dealers or Sales Representatives	209	25.3	51.7	23.0
10	Television	207	44.4	41.1	14.5
11	Alabama Agricultural Experiment Station Scientists	193	22.3	49.7	28.0
12	Cooperative Extension Service Publications	182	35.7	45.6	18.7
13	Cooperative Extension Service Specialists	181	22.7	52.4	24.9
14	Publications of Farm Organizations	178	41.0	41.6	17.4
15	County SCS Office	171	18.8	49.6	31.6
16	Machinery Dealers or Sales Representatives	170	17.1	55.8	27.1
17	Handbooks and Textbooks	164	26.8	51.9	21.3
18	Chemical Dealers or Sales Representatives	164	21.3	50.0	28.7
19	Field Days, Tours, and Demonstrations	145	7.6	39.3	53.1
20	Alabama Agricultural Experiment Station Publications	143	24.5	44.7	30.8
21	Local Experiment Stations	137	13.2	48.1	38.7
22	"Highlights of Agricultural Research"	106	33.9	40.6	25.5

TABLE 3--Continued

Rank	Sources of Information	Total Number Reporting Use	Pct. Reporting Different Frequencies		
			Daily to Once a Month	Once a Month to Once a Year	Once a Year or Less
23	Vocational Agriculture Teacher	87	34.4	38.0	27.6
24	Meetings at Auburn University	49	4.0	30.6	65.4
	Sample Size	380			

Information Needs and Sources of Alabama Farmers

kinds of information. These data are too detailed to present in their entirety in a journal article. However, some important points can be presented here. Perhaps the most important point to be noted is the extremely important place farm magazines play as a source for a wide variety of information reported needed by Alabama farmers.

Sources for Prices of Crops and Livestock

For crop and livestock prices, radio was the most reported source. Soybean prices were an exception, however, where radio ranked second to newspapers. Newspapers and television were among the top three sources reported for all the crop prices and were in the top four sources for livestock prices, along with farm magazines. "Other farmers" were an important source of all kinds of price information ranking fourth or fifth in each case. Farm magazines ranked second for livestock prices and fourth or fifth for all crop prices. Other important sources of price information were farm supply stores and cooperatives, the Alabama Crop and Livestock Reporting Service, the County Extension Office, elevators and brokers, and market reports.

Sources for Fertilizer, Insecticide, and Herbicide Information

Kind and amount of a wide array of fertilizers and farm chemicals are some of the more important kinds of information reported needed by Alabama farmers. Fertilizer or chemical dealer or sales representative were the most frequent sources mentioned for four of the six kinds of information of this type mentioned as needed. Farm supply stores and cooperatives ranked first for the other two and second for the previous four. "Other farmers" and the County Extension Office ranked third or fourth for all the six categories for this type of information. Other important sources of this type of information were farm magazines, Agricultural Experiment Station scientists, Extension Service specialists, Experiment Station publications, Extension Service publications, local Experiment Stations², and the Soil Test Laboratory at Auburn University.

Sources for New Farm Practices, Crop and Livestock Varieties and Breeds, and New Farm Enterprises

Innovations of all kinds seemed to have a common pattern whether or not they pertained to practices, varieties, breeds, or enterprises. Farmers listed farm magazines as the number one source for all of these kinds of information characterized by the word "new." "Other farmers" and the County Extension Office ranked either second or third for all information of this type. After these three sources, farmers listed a variety of sources for innovations but Extension Service specialists, Agricultural Experiment Station scientists, Agricultural Experiment

²Substations of the Main Agricultural Experiment Station at Auburn. These substations are located at 20 locations throughout the state and conduct research on crops and commodities important to the area.

Station publications, and Extension Service publications were all mentioned and all ranked in the top 10 sources for information of this type. Therefore, after magazines and "other farmers," the Extension Service and the Experiment Station system were important sources for this type of information. And, it is quite likely that the sources for magazines and "other farmers" were from these sources also. Local Experiment Stations were mentioned often as were field days, tours, and demonstrations carried out separately or jointly by the Extension Service and the Agricultural Experiment Station system. Other sources ranking in the top 10 for this kind of information were farm supply stores and cooperatives, handbooks and textbooks, and newspapers.

Sources for Other Kinds of Information

The sources for the rest of the various kinds of information show a more varied pattern.

The first five sources for livestock disease information, in order of rank, were farm magazines, "other farmers," the County Extension Office, farm supply stores and cooperatives, and Extension Service specialists.

The first six sources for Federal Government Programs and Federal Government Regulations were the County Agricultural Stabilization and Conservation Service Office, farm magazines, the County Soil Conservation Service, the County Extension Office, newspapers, and "other farmers." It is not surprising that the two Federal Government agencies were major sources of this kind of information as they are charged with administration of the programs and regulations.

Information on what machinery to buy and machinery repair methods most often came, as expected, from machinery dealers, "other farmers," and farm magazines in that order.

Federal income tax information came from a variety of sources. Farm magazines again ranked first, as they have in a wide variety of information needed by farmers.

Expected yields were obtained most often from "other farmers," farm magazines, and the County Extension Office.

Hedging information was most often obtained from farm magazines. Farm leasing and tenure arrangements were most often obtained from "other farmers" and farm magazines.

Sources by Commodity Groups

While there was generally no great difference in use of most sources of information by commodity groups, there were exceptions.

Generally, all commodity groups used farm magazines, "other farmers," and farm supply stores and cooperatives a high percentage of the time, Table 4.

TABLE 4
 PERCENTAGE OF FARMERS IN DIFFERENT COMMODITY GROUPS REPORTING A USE
 OF THE DIFFERENT SOURCES OF INFORMATION, ALABAMA, 1976

Sources of Information	Commodity Groups									
	Livestock					Row Crops				
	Beef	Poultry	Pork	Dairy	Feed Grains	Soybeans	Peanuts	Cotton	Percent	
<i>Print Media</i>										
Farm Magazines	85.8	80.3	86.2	91.9	83.2	89.9	89.1	84.0		
Crop and Livestock Reporting Service	66.0	54.1	63.8	64.9	64.0	70.7	68.8	60.0		
Newspapers	65.7	53.3	66.0	56.8	62.4	72.7	67.2	81.1		
Extension Service Publications	51.9	33.6	55.3	48.6	53.8	58.6	70.3	64.0		
Publications of Farm Organizations	49.6	39.3	46.8	50.0	46.7	54.5	51.6	60.0		
Handbooks	46.3	38.5	46.8	45.9	45.7	51.5	48.4	64.0		
Experiment Station Publications	39.2	24.6	44.7	39.2	46.2	47.4	56.3	48.0		
"Highlights of Agricultural Research"	29.1	22.1	27.7	33.8	34.5	39.4	37.5	28.0		
<i>Electronic Media</i>										
Radio Programs	58.6	55.7	61.7	47.3	56.3	68.7	59.4	72.0		
Television	58.2	50.0	66.0	55.4	55.3	69.7	76.6	60.0		
<i>Personal Sources</i>										
Other Farmers	79.9	73.8	74.5	82.4	79.2	86.9	79.7	80.0		
Farm Supply Stores and Coops	73.1	71.3	73.4	71.6	69.0	72.7	68.8	72.0		
County ASC Office	69.4	54.9	69.1	44.7	67.5	74.7	82.8	80.0		
County Extension Chairman or His Staff	69.4	53.3	72.3	63.5	68.0	70.7	84.4	76.0		
Fertilizer Dealer or Sales Representative	59.3	44.3	68.1	56.8	59.9	70.7	67.2	60.0		
Experiment Station Scientist	53.4	38.5	51.4	51.4	55.8	61.6	70.3	48.0		
Extension Specialist	50.7	32.8	57.4	52.7	53.3	58.6	68.8	56.0		

TABLE 4--Continued

Sources of Information	Commodity Groups													
	Livestock					Row Crops								
	Beef	Poultry	Pork	Dairy	Feed Grains	Soybeans	Peanuts	Cotton	Percent					
<i>Personal Sources--Continued</i>														
County SCS Office	50.4	40.2	47.9	39.2	44.2	54.5	60.9	60.0						
Machinery Dealer or Sales Representative	48.1	40.2	48.9	44.6	47.2	59.6	57.8	60.0						
Chemical Company Representative	46.6	34.4	55.3	47.3	54.3	66.7	59.4	56.0						
Field Days, Tours, and Demonstrations	39.9	27.0	48.9	50.0	44.7	52.5	56.3	40.0						
Local Experiment Stations	40.3	25.4	48.9	37.8	48.7	48.5	57.8	52.0						
Vocational Agriculture Teacher	23.9	23.0	26.6	20.3	25.4	25.3	17.2	24.0						
Meetings at Auburn University	14.6	6.6	11.7	14.9	14.7	17.2	21.9	12.0						
Meetings at Alabama A&M University	1.5	1.6	2.1	5.4	2.0	2.0	0.0	8.0						
Meetings at Tuskegee Institute	1.1	0.8	1.1	4.1	0.5	0.0	1.6	0.0						
<i>Sample Size</i>	268	122	94	74	197	99	64	25						

Information Needs and Sources of Alabama Farmers

As expected, farmers with controlled crops such as cotton and peanuts used Agricultural Stabilization and Conservation Service offices more and dairy and poultry farmers used them less.

Peanut farmers used the County Extension Office more than any other commodity group. For all commodity groups but poultry, nearly two-thirds or more of the farmers reported using this source of information.

Cotton farmers were frequent users of newspapers and radio, as were soybean farmers. Peanut farmers led in use of television. Peanut farmers also were the most frequent users of all sources of information followed by soybean farmers and cotton farmers, while poultry farmers were the least frequent users of all sources.

Sources by Farm Income Levels

One important generalization that can be made concerning income levels is that use of different sources of information goes up as gross farm income levels rise, Table 5. However, this may vary for certain specific cases. One exception, which appears for some sources of information, is a downturn in percent of use after reaching certain higher income levels, especially \$200,000 and over.

Sources by Education Levels

As with income, it was expected that different sources of information would be used more as education levels rose and this appeared generally true from the data, Table 6. Again, however, there were some exceptions in specific cases.

The relationship was especially true for sources requiring reading such as farm magazines, newspapers, and the various other published materials. It was less so for radio and television.

Sources by Age Level

There was no consistent relationship between age and use of different specific sources of information, Table 7. This is probably because age is associated with the other factors tested. For instance, as age rises, farmers tend historically to have less formal education. On the other hand, as age rises, and a farmer gains experience and capital, gross farm income rises. These factors, no doubt, confuse any association between age itself and use of different specific sources of information. There was, however, a general tendency for farmers to use all sources of information less as age increased; or, conversely, for younger farmers to use all sources more.

SUMMARY AND CONCLUSIONS

A mail survey was sent to 1,335 Alabama farmers in 1977 asking them what kinds of information they needed for their farm operations and the sources of information they used for different kinds of information. About a third of the questionnaires were returned (436) which

TABLE 5
 PERCENTAGE OF FARMERS IN DIFFERENT GROSS FARM INCOME LEVELS REPORTING A
 USE OF THE DIFFERENT SOURCES OF INFORMATION, ALABAMA, 1976

Sources of Information	Gross Farm Income Levels							Percent
	\$2,499 and Under	\$2,500- 9,999	\$10,000- 39,999	\$40,000- 99,999	\$100,000- 199,000	\$200,000 and Over		
<i>Print Media</i>								
Farm Magazines	58.4	76.8	88.7	98.1	90.6	84.6		
Crop and Livestock Reporting Service	39.0	51.2	63.7	76.9	68.8	61.5		
Newspapers	36.4	62.2	62.9	73.1	62.5	61.5		
Extension Service Publications	13.0	41.5	44.4	69.2	78.1	61.5		
Publication of Farm Organizations	22.1	43.9	52.4	59.6	56.3	53.8		
Handbooks	19.5	37.8	48.4	51.9	50.0	61.5		
Experiment Station Publications	22.2	31.7	36.3	51.9	59.9	61.5		
"Highlights of Agricultural Research"	11.7	18.3	27.4	36.5	50.0	61.5		
<i>Electronic Media</i>								
Radio Programs	36.4	50.0	61.3	61.5	62.5	53.8		
Television	31.2	52.4	56.5	73.1	56.3	53.8		
<i>Personal Sources</i>								
Other Farmers	50.6	72.0	80.6	94.2	81.3	76.9		
Farm Supply Stores and Cooperatives	45.5	70.0	74.2	71.2	71.9	53.8		
County ASC Office	49.4	56.1	65.3	78.8	72.5	53.8		
County Extension Chairman or His Staff	35.1	53.7	62.9	82.7	90.6	69.2		
Fertilizer Dealer or Sales Representative	22.1	53.7	57.3	69.2	78.1	69.2		
Experiment Station Scientist	28.6	41.5	48.4	75.0	71.9	61.5		
Extension Specialist	24.7	34.1	42.7	76.9	81.3	61.5		
County SCS Office	23.4	34.1	46.8	63.5	56.3	53.8		
Machinery Dealer or Sales Representative	13.0	32.9	51.6	63.5	68.8	61.5		

TABLE 5--Continued

Sources of Information	Gross Farm Income Levels							Percent
	\$2,499 and Under	\$2,500-9,999	\$10,000-39,999	\$40,000-99,999	\$100,000-199,999	\$200,000 and Over		
<i>Personal Sources--Continued</i>								
Chemical Company Representative	13.0	25.6	49.2	67.3	65.6	84.6		
Field Days, Tours, and Demonstrations	10.4	23.2	39.5	63.5	68.8	69.2		
Local Experiment Stations	10.4	28.0	35.5	59.6	59.4	61.5		
Vocational Agriculture Teacher	18.2	20.7	22.6	26.9	25.0	23.1		
Meetings at Auburn University	5.2	3.7	10.5	23.1	31.3	46.2		
Meetings at Alabama A&M University	0.0	0.0	2.4	3.8	0.3	0.0		
Meetings at Tuskegee Institute	0.0	1.2	1.6	1.9	0.0	7.7		
<i>Sample Size</i>	77	82	124	52	32	13		

TABLE 6
 PERCENTAGE OF DIFFERENT EDUCATION LEVELS USING DIFFERENT SOURCES
 OF INFORMATION, ALABAMA, 1976

Sources of Information	Formal Education					
	1-4 Years	5-8 Years	9-12 Years	13-16 Years	17 Years or More	Percent
<i>Print Media</i>						
Farm Magazines	33.3	66.0	86.8	95.2	95.0	95.0
Crop and Livestock Reporting Service	25.0	38.3	64.4	66.3	70.0	70.0
Newspapers	33.0	42.6	63.9	66.3	70.0	70.0
Extension Service Publications	8.3	27.7	48.8	50.6	55.0	55.0
Publications of Farm Organizations	0.0	23.4	45.9	66.3	70.0	70.0
Handbooks	0.0	14.9	42.4	60.2	70.0	70.0
Experiment Station Publications	8.3	14.9	35.6	53.0	55.0	55.0
"Highlights of Agricultural Research"	0.0	17.0	24.9	45.8	45.0	45.0
<i>Electronic Media</i>						
Radio Programs	33.3	38.3	58.6	63.9	55.0	55.0
Television	33.3	46.8	55.1	61.4	55.0	55.0
<i>Personal Sources</i>						
Other Farmers	41.7	53.2	79.5	94.0	80.0	80.0
Farm Supply Stores and Cooperatives	41.7	55.3	73.2	65.1	90.0	90.0
County ASC Office	25.0	53.2	66.8	66.3	70.0	70.0
County Extension Chairman or His Staff	25.0	48.9	62.9	73.5	75.0	75.0
Fertilizer Dealer or Sales Representative	16.7	40.4	57.6	61.4	70.0	70.0
Experiment Station Scientist	16.7	27.7	52.7	63.9	55.0	55.0
Extension Specialist	8.3	25.5	49.8	62.7	40.0	40.0
County SCS Office	8.3	23.4	41.0	55.4	55.0	55.0
Machinery Dealer or Sales Representative	16.7	25.5	46.8	53.0	60.0	60.0

TABLE 6--Continued

Sources of Information	Formal Education					
	1-4 Years	5-8 Years	9-12 Years	13-16 Years	17 Years or More	Percent
<i>Personal Sources--Continued</i>						
Chemical Company Representative	0.0	34.0	42.9	56.6	50.0	
Field Days, Tours, and Demonstrations	0.0	27.7	31.2	62.7	55.0	
Local Experiment Stations	0.0	25.5	32.2	61.4	30.0	
Vocational Agriculture Teacher	0.0	12.8	22.4	33.7	30.0	
Meetings at Auburn University	0.0	4.3	9.8	25.3	25.0	
Meetings at Alabama A&M University	0.0	0.0	2.4	2.4	0.0	
Meetings at Tuskegee Institute	0.0	0.0	1.5	1.2	5.0	
<i>Sample Size</i>	12	47	205	83	20	

TABLE 7
 PERCENTAGE OF DIFFERENT AGE LEVELS USING DIFFERENT
 SOURCES OF INFORMATION, ALABAMA, 1976

Sources of Information	Age of Operator				
	30 Years and Under	31-40 Years	41-50 Years	51-60 Years	Over 60 Years
	Percent				
<i>Print Media</i>					
Farm Magazines	90.9	85.1	90.7	82.5	81.0
Crop and Livestock Reporting Service	72.7	66.0	61.6	57.9	57.1
Newspapers	72.7	70.2	65.1	61.9	47.6
Extension Service Publications	54.5	44.7	50.0	49.2	46.4
Publications of Farm Organizations	81.8	53.2	54.7	40.5	39.3
Handbooks	63.6	55.3	53.5	34.1	33.3
Experiment Station Publications	40.9	31.9	43.1	34.9	35.7
"Highlights of Agricultural Research"	36.4	34.0	27.9	24.6	23.8
<i>Electronic Media</i>					
Radio Programs	77.3	61.7	67.4	49.2	46.4
Television	81.8	63.2	59.3	51.6	48.8
<i>Personal Sources</i>					
Other Farmers	95.5	87.2	87.2	74.6	65.5
Farm Supply Stores and Cooperatives	86.4	74.5	75.6	68.3	56.0
County ASC Office	63.6	63.8	66.3	57.1	71.4
County Extension Chairman or His Staff	72.7	63.8	67.4	61.9	57.1
Fertilizer Dealer or Sales Representative	59.1	61.7	64.0	52.4	47.6
Experiment Station Scientist	59.1	51.1	50.0	48.4	53.6
Extension Specialist	68.2	46.8	52.3	46.8	39.3
County SCS Office	64.6	27.7	53.5	40.5	33.3
Machinery Dealer or Sales Representative	77.3	44.7	58.1	42.9	28.6

TABLE 7--Continued

Sources of Information	Age of Operator				
	30 Years and Under	31-40 Years	41-50 Years	51-60 Years	Over 60 Years
	Percent				
<i>Personal Sources--Continued</i>					
Chemical Company Representative	59.1	40.4	58.1	42.1	29.8
Field Days, Tours, and Demonstrations	50.0	36.2	39.5	39.7	33.3
Local Experiment Stations	36.4	31.9	36.0	41.3	32.1
Vocational Agriculture Teacher	31.8	25.5	26.7	18.3	23.8
Meetings at Auburn University	18.2	12.8	14.0	12.7	11.9
Meetings at Alabama A&M University	0.0	2.1	2.3	2.4	0.0
Meetings at Tuskegee Institute	4.5	0.0	2.3	1.6	0.0
<i>Sample Size</i>	21	47	86	126	84

is usual for a mail survey of this type. Analysis was made by eight commodity groups, different gross income levels, education levels, and age of operator.

Livestock prices were the single most important category of information reported needed by Alabama farmers, followed by kind and quantity of fertilizer to use. Other important categories of information needed were livestock disease information, kind and how to apply herbicides, new farm practices, Federal Government programs, type of farm machinery to buy, machinery repair methods, and new crop varieties, among others.

Farm magazines were the single most important source of information and were mentioned by nearly 85 percent of the farmers. They ranked high for a wide variety of kinds of information. They also were used more frequently than any other source. Radio, newspapers, and television also were important sources for a wide variety of livestock and crop price information.

There was little difference in use of different sources of information by commodity groups except that peanut farmers were the highest average users of all sources of information and poultry farmers were the lowest. By income levels, generally, use of all sources increased as incomes rose except at high income levels. This was also true of education levels. There was little difference in use of different specific sources of information by age level except that all sources tended to be used less as age increased.

RURAL REAL ESTATE MARKETS IN MAJOR
AGRICULTURAL AREAS OF ALABAMA¹

John L. Adrian, Jr.

*Department of Agricultural Economics and Rural Sociology
Auburn University
Auburn, AL 36830*

Rural real estate values have exhibited high rates of appreciation in recent years. Between 1970 and 1979, the national average farm real estate value increased from \$195 to \$559 per acre, a 187 percent jump (11). Similar increases have been noted for Alabama. The average value of rural real estate in Alabama rose from \$200 in 1970 to \$515 in 1979, a 158 percent increase. The largest increases during this period occurred in the U.S. and Alabama between 1973 and 1974--25 and 27 percent, respectively. These rapid increases in value have generated much interest in the rural land market from both agricultural and non-agricultural sources.

The primary objective of this analysis was to determine the nature and structure of the rural real estate market in three important agricultural areas of Alabama. Availability of structural parameters explaining the relative importance of various factors influencing the value of alternative tracts of property and general characteristics of land transactions can facilitate operation of the market system by providing information to public and private (farm and nonfarm) decision-makers.

STUDY AREAS

Alabama agriculture is diversified due to differences in physical, biological, economic, and institutional characteristics inherent to particular areas of the State. The rural land market is affected by variations in and interaction of these factors. An analysis of variations in rural land value should recognize this and concentrate on regions exhibiting similar general characteristics. Since soil type influences agricultural production and general soil regions of Alabama are documented, study areas were delineated utilizing the major soil areas of Alabama (4). Land located in the Black Belt, Wiregrass (southeastern lower coastal plains), and Limestone Valley was included in the analysis, Figure 1.

The Black Belt region is a geological area which includes large portions of 11 central Alabama counties. This area is characterized by

¹Manuscript received 24 September 1979; accepted 13 February 1980.

dark colored calcareous clay soils and gray to red acid clay soils. Major agricultural enterprises in this region are beef and milk cattle, soybeans, cotton, and catfish. Logs and pulpwood are also important products of the region and the woodlands which produce these products also support an abundance of wildlife. The Alabama, Black Warrior, and Tombigbee rivers provide major sources of water for the area.

The Wiregrass region includes nine southeastern counties in Alabama. The land consists of gently rolling to hilly woodlands that are dominated by pine trees. There are large areas of open-land used for cultivated crops and pasture. Deep soils with sandy surface layers are common. Major income producing agricultural enterprises in this region are peanuts, cattle and calves, hogs, broilers, soybeans, and corn. Forest products are also a major source of income. The Chattahoochee River is a navigable waterway that borders the region. Other water resources in the area are the Conecuh and Pea Rivers and Lake Eufaula.

The Limestone region which includes major portions of 11 counties is so-named because its soils were derived from limestone. This region is concentrated in the Tennessee and Limestone Valley areas of the State. The Tennessee Valley, located in the Tennessee River basin in the extreme northern counties, has high fertility and intensive agriculture. The Limestone Valley consists of a series of limestone valleys of moderate width lying between wooded hills and ridges, generally along the Coosa River basin. Major agricultural enterprises in this region are broilers, cattle and calves, hogs, soybeans, cotton, and eggs.

METHODOLOGY

Rural land was classified as real estate located outside the confines of municipalities excluding such special use categories as rural highways, railroads, airports, parks, wildlife refuges, national defense areas, and flood control projects. Land contiguous to these excluded areas was included in the analysis. Also excluded were sales of less than 10 acres and transactions which were land trades, foreclosures, tax sales, sales between relatives, and sales transacted under compulsion.

Within each of the three regions, a listing of qualified land transactions was obtained from deed records in the respective counties. Data were collected between October 1974 and August 1975 for the Black Belt, February and May 1976 for the Wiregrass, and January and June 1977 for the Limestone Valley. From these listings, stratified random samples of tracts were selected in proportion to their frequency of occurrence. Forty-nine transactions were selected in the Black Belt while 75 and 76 were selected in the Wiregrass and Limestone regions, respectively. Both buyers and sellers were interviewed to ascertain their characteristics as well as the physical, locational, sale, and ownership characteristics for the transferred parcel of property.

Multiple regression analysis was utilized to isolate and analyze the impact of these factors in explaining variation in real estate values. Also, the data were used to profile the participants in the transactions as well as the transaction itself. Using this profile, along with data

on the relative magnitude and significance of factors in the model, structural components of the rural real estate market were determined.

MODEL

Three categories of variables were included in the statistical model: locational, physical and sales, and type of ownership. Land is fixed in location and found at varying distances from centers of social and economic activity. Costs are involved in transferring the output from rural land to markets in population centers; in bringing labor, capital, and other inputs from economic centers to land; and in acquiring the goods and services available in towns and cities. Therefore, location plays an important role in determining economic uses of land and in affecting the rent and value attached to its use. Clonts and Gibson (2); Wise, Dover and Miller (12); Bryant (1); and Edwards (3) found that distance to population centers had a negative effect on rural land value; that is, as distance increased, value declined. This basic relationship was believed to exist for property in Alabama; however, the decline was not hypothesized to be constant. Thus, a quadratic function was specified for location with respect to cities of more than 25,000 population to test this relationship. Other factors such as population density in the area and location of the parcel relative to the buyer's residence and a navigable river were also hypothesized to influence value. Tracts of land located in more densely populated areas should command higher prices because of the increased number of potential buyers. Similarly, parcels located near navigable waterways should be more valuable because of irrigation, recreation, and transportation potential. Also, buyers may be willing to pay more for parcels located near their residence because such land is often infrequently sold and acquisition and use of it could improve efficiency of their existing operation.

Physical and sales characteristics analyzed were: value of improvements (farm and residential), percent cropland, tract size, purchase for farming, type of sale, and presence of a pond or stream, paved road frontage, or a community water line. These factors represent attributes a particular tract of land or transaction possesses or exhibits which make it attractive or unattractive to potential buyers.

Improvements are man-made structures such as houses, barns, or fences which are fixed to the land. Several real estate studies have analyzed the impact of improvements on value. An analysis of land parcels in Nebraska, with and without buildings, showed no important or consistent per acre differences in value, although the average price per tract without buildings was less (5; p. 9). Mandale and Raup (8) reported unimproved land averaged 80 percent less than the sales price of improved land in Wisconsin. Similarly, Wise, Dover and Miller (12) found that improvements had a significant positive effect on land values in North Georgia. The value of improvements was expected to contribute to the value of land parcels in this analysis. However, since the contribution was expected to differ between farm and residential improvements, a separate variable was entered for each.

Openland, cropland and pastureland, uses were expected to have a positive effect on value relative to other agricultural uses such as

timberland. This is due to the productivity and income potential of these higher valued uses in agriculture. Thus, as the percent of openland in a particular tract increased, value per acre was expected to increase.

Tract size was found to be inversely related to value by Johnson (5) and Wise (12). As tract size increases, so does the initial investment or money outlay required for a land purchase. Large expenditures limit entry of some potential buyers into the market because of the financial constraint. Also, high valued uses of land such as residential and industrial development often require less land than lower valued uses such as farming. Thus, value per acre was hypothesized to decline as tract size increased.

Farming is a lower valued use of land relative to industrial, residential, or recreational uses. Thus, purchase for farming was expected to have a negative impact on value because the potential income producing capability is less relative to the development uses.

Type of sale (by owner or broker) was expected to influence the final sale price for land. Brokers are usually better informed and knowledgeable of the land market and are generally in contact with more potential buyers than the owner. Thus, transfer of a tract of land by the owner was expected to have a negative influence on the price paid relative to a broker negotiated exchange.

The presence of water resources, ponds and/or streams, enhances potential uses for rural land such as livestock watering, fish production and recreation. Thus, the availability of water resources was expected to have a positive effect on value.

Presence of paved road frontage and community water lines increase the feasibility of alternative uses for a tract of land, especially residential and development uses. Therefore, the presence of these factors was hypothesized to contribute to higher values.

Four types of ownership were considered in this study: individual, partnership, corporation, and estate. Financial resources generally increase as the number of persons buying as a unit increases. Thus corporations and partnerships should be in better financial condition to bid a higher price for land relative to individuals. However, corporations or partnerships would not be so inclined without market pressure. Due to these divergent impacts, no hypothesis was made concerning the effect of type of buyer on value.

A tract of land may be sold by either of the ownership types. In transactions involving estates, heirs often have little knowledge of the property, are often not interested in maintaining the property, and may not live in proximity of the property. Land in an estate is sold for the purpose of meeting claims against the estate. Thus, the sales price received is expected to be lower for sales involving estates relative to non-estate sales.

The real estate value model specified using these factors was:

$$V = a + b_1L_1 + b_2L_2 + b_3L_2^2 + b_4L_3 + b_5L_4 + b_6P_1 + b_7P_2 + b_8P_3 + b_9P_4 + b_{10}P_5 + b_{11}P_6 + b_{12}P_7 + b_{13}P_8 + b_{14}P_9 + b_{15}T_1 + b_{16}T_2$$

where:

V = per acre value (dollars) of real estate.

Location variables were:

- L₁ = population density (people per square mile) of county census district in which the parcel was located.
- L₂ = distance (miles) property was from a city of greater than 25,000 population by road.
- L₃ = distance (miles) property was from a navigable river by road.
- L₄ = distance (miles) property was from the buyer's residence by road.

Physical and sales characteristics of a parcel of property were:

- P₁ = value (dollars) of farm improvements per acre.¹
- P₂ = value (dollars) of residential improvements per acre.¹
- P₃ = percent of the property which was open; i.e., cropland or pastureland.
- P₄ = 1 if a pond, all weather stream, or river frontage was present on the property and = 0 otherwise.
- P₅ = 1 if the property had paved road frontage and = 0 otherwise.
- P₆ = 1 if the property had a community water line available and = 0 otherwise.
- P₇ = size of the property in acres.
- P₈ = 1 if the property was purchased for farming and = 0 otherwise.
- P₉ = 1 if the buyer negotiated the price with the owner and = 0 otherwise.

Type of ownership variables were:

- T₁ = 1 if the buyer was an individual and = 0 otherwise (corporation or partnership).
- T₂ = 1 if the seller was an estate and = 0 otherwise.

The rural land market is complex in that numerous variables affect the market value of farm real estate. The variables included in the statistical model reflect the impact of factors expected to affect rural real estate value.

RESULTS

The average size of transferred parcels was substantially larger in the Black Belt (108 acres) and Wiregrass (175 acres) regions than in the

¹Values were based on estimates by the buyer and seller at the time of sale.

Rural Real Estate Markets

Limestone Valley (56 acres) area, Table 1. However, the average percentage of openland per tract was similar among regions, 50 percent. About one-fourth of the tracts had dwellings present. Residential improvements were a more important component of value in the Limestone region (32%) than in the Wiregrass (8%) or Black Belt (22%) areas. Farm improvements contributed relatively little to value in either region. Nonagricultural influences were more evident in the Limestone area as indicated by the availability of community water lines and road frontage. Ponds and streams were more prevalent on parcels in the Wiregrass and Black Belt regions.

Individuals were the dominant buyers of land; however, partnerships were important in the Wiregrass region. Farming was an important reason for land purchase. Almost half of the Wiregrass area buyers and 24 and 40 percent of the Limestone and Black Belt purchasers, respectively, had farm income. This coupled with the fact that approximately half of the Limestone and Wiregrass buyers and a third of the Black Belt buyers owned adjacent property indicated the relative importance of farm expansion in the land market. The importance of nonagricultural factors was exhibited by the fact that home and speculation and development were important reasons for land purchases.

Income was the primary reason land was sold while age of the seller was another frequent response. Approximately a fifth of the transferred parcels were owned for less than one year and slightly over a third were held for three years or less by the seller. In general, turnover was slightly greater for property in the Limestone region.

Eighty-four percent or more of the variation in the per acre value of rural real estate in these regions was explained by the estimated models, Table 2. Location of a parcel relative to cities of greater than 25,000 population was significant in all models. As distance from cities of this size increased, value per acre decreased at a decreasing rate; that is, the relationship was curvilinear, Figure 2. Distance to a navigable river also had an important impact on value in the Black Belt region. Value declined by about \$7 per acre for each mile the property was from a navigable river.

Each additional dollar of farm improvement value contributed about \$1.50 to value in the Limestone and Wiregrass areas. Also, in these regions, residential improvements significantly contributed to value. However, the contribution was less than dollar for dollar. In the Black Belt, each additional dollar of residential improvements added \$1.10 to real estate value. The standard error for the farm improvements coefficient was relatively large. Percent cropland, paved road frontage, and presence of a community water line were other significant physical characteristics. Parcels in the Limestone Valley which had paved road frontage commanded \$289 more per acre than those lacking such frontage. Also, tracts having a community water line present had per acre values which were \$238 greater than similar tracts without water lines. In the Black Belt region, each additional percent of openland available added almost \$1.60 to value.

TABLE 1. Characteristics of Land Transactions in Major Agricultural Areas of Alabama.

Characteristic	Units	Limestone Valley	Wiregrass	Black Belt
TRACT:				
Size	Acre	56	175	108
Farm improvements value per total value	Pct.	3	3	2
Residential improvements value per total value	Pct.	32	8	22
Dwelling present	Pct.	28	19	28
Community water present	Pct.	41	3	12
Pond or stream present	Pct.	44	68	71
Road frontage present	Pct.	88	61	73
Openland	Pct.	50	49	57
BUYER:				
Type--Corporation	Pct.	6	8	6
Partnership	Pct.	4	19	8
Individual	Pct.	90	73	86
Reason for purchase				
Home	Pct.	19	5	20
Farming	Pct.	23	52	37
Home and farming	Pct.	24	21	22
Speculation and development	Pct.	28	19	17
Other	Pct.	6	3	4
Own adjacent property	Pct.	46	32	33
Having farm income	Pct.	24	49	40
SELLER:				
Reason for selling				
Income	Pct.	52	61	62
Age	Pct.	14	29	10
Divide among heirs	Pct.	7	7	16
Distance	Pct.	14	3	0
Other	Pct.	13	0	12
Span of ownership				
1 or less years	Pct.	16	21	18
3 or less years	Pct.	41	36	34
5 or less years	Pct.	54	47	38
10 or less years	Pct.	66	60	56

Rural Real Estate Markets

TABLE 2. Structural Models of Rural Real Estate Markets in the Limestone (1977), Wiregrass (1976) and Black Belt (1975) Regions of Alabama.

Factor	Limestone Valley	Wiregrass	Black Belt
	----- dollars -----		
Intercept	1,370.01* (327.18)***	864.16* (105.91)	1,283.68* (210.23)
Location:			
Population density (L ₁)	-1.51 (1.14)	-0.07 (0.07)	0.88 (1.41)
Distance to city 25,000 population (L ₂)	-60.61* (22.52)	-18.98* (3.87)	-44.67* (9.16)
Distance squared to city 25,000 population (L ₂ ²)	0.90* (0.46)	0.16* (0.04)	0.61* (0.15)
Distance to navigable river (L ₃)	7.29 (6.25)	1.53 (1.15)	-6.85* (3.20)
Distance to buyer's residence (L ₄)	-0.02 (0.42)	-0.37 (0.32)	0.03 (0.06)
Physical and Sale Characteristics:			
Farm improvements per acre (P ₁)	1.59* (0.81)	1.37* (0.28)	1.03 (1.47)
Residential improvements per acre (P ₂)	0.81* (0.06)	0.93* (0.09)	1.10* (0.07)
Percent openland (P ₃)	215.15 (138.52)	9.90 (55.33)	156.73** (90.56)
Fond or stream present (P ₄)	-21.27 (105.88)	25.69 (39.97)	23.10 (80.25)
Paved road frontage (P ₅)	288.84* (127.51)	28.40 (49.65)	95.97 (72.24)
Community water line present (P ₆)	237.60** (125.07)	121.28 (105.96)	133.04 (111.26)
Tract size (P ₇)	-2.42* (1.08)	-0.20 (0.15)	-0.26 (0.17)
Purchase for farming (P ₈)	-203.45 (129.12)	3.01 (37.12)	-177.85* (72.76)
Type of sale (P ₉)	49.53 (130.25)	-127.22* (59.34)	-0.67 (69.98)
Type of Owner:			
Individual buyer (T ₁)	6.56 (170.75)	20.69 (43.87)	-88.54 (86.64)
Estate seller (T ₂)	-27.70 (211.32)	38.69 (71.72)	-144.80 (89.39)
Coefficient of determination (pct.)	.88	.84	.95
Standard error of the estimate	407	139	189

*Significant at .01 level.

**Significant at .10 level.

***Figures in parentheses are standard errors.

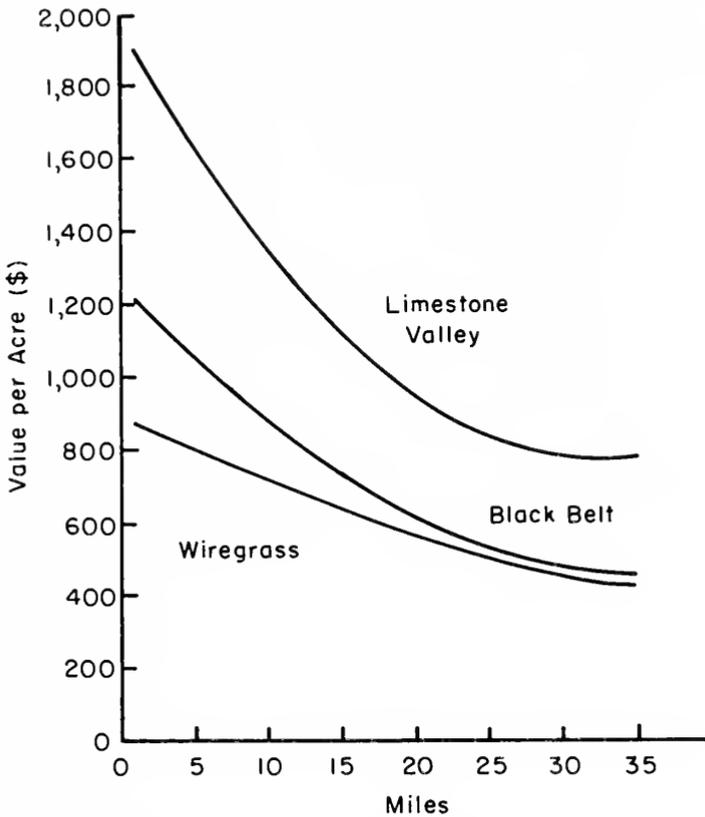


Figure 2. Relationship of Rural Real Estate Value Per Acre to Distance to a City of Greater than 25,000 Population with Other Factors Entered at the Mean.

NOTE: Values must be adjusted for appreciation before regional comparisons of value can be made.

Tract size was a significant sale characteristic in the Limestone Valley while type of sale and purchase for farming were important in the Wiregrass and Black Belt regions, respectively. Each additional acre in a tract in the Limestone Valley reduced value by \$2.42 per acre. In the Wiregrass, sellers who negotiated the transaction rather than using a broker or auction received less per acre. Similarly, transactions involving purchase of land for farming in the Black Belt evidenced lower value per acre than did transactions for nonagricultural uses.

Rural Real Estate Markets

CONCLUSIONS

The analysis indicated that the rural land market in these areas was primarily agricultural but had strong influences from the nonagricultural sector, especially in the Limestone Valley. Forty-seven, 73, and 59 percent of the transactions made in the Limestone, Wiregrass, and Black Belt regions, respectively, were for farming and home and farming purposes. In contrast, 47, 24, and 37 percent of the transactions in the respective regions were for home and speculation and development reasons.

There was a fairly rapid turnover of property in these areas. Approximately a fifth of the transactions involved property that was owned for one or less years. Almost 50 percent of the parcels were held for 5 years or less in the Limestone and Wiregrass areas while only slightly over a third were held for 5 years or less in the Black Belt region.

Nonagricultural factors will become increasingly important to the rural land market in the future especially in proximity of cities having 25,000 or more population. High land prices coupled with low farm returns could force important changes in land use and tenure patterns in these areas. Already, it is questionable whether typical farm incomes justify land prices in sections of these regions. Without fairly rapid rates of appreciation in farmland values, it is doubtful whether farmers could purchase and hold such property. Indications are that rural land will tend to shift to higher value uses, especially when tract sizes are small. Small acreage and part-time farmer's ability to remain as viable units will greatly affect this situation.

SELECTED REFERENCES

- (1) Bryant, William R. 1974. The Rural Land Market in Wayne County, New York. A.E. Res. 74-8. Cornell Univ. Agr. Exp. Sta.
- (2) Clonts, H. A. and W. L. Gibson. 1971. Land Values in the Rural-Urban Fringe. V.P.I. and St. Univ. Res. Bull. 58.
- (3) Edwards, Jack D., Wilfred H. Pine and Arlin M. Feyerherm. 1964. Effects of Roads and Other Factors on Farm Real Estate Values in Kansas. Agr. Exp. Stat. Bull. 469, Kan. St. Univ.
- (4) Hajek, B. F., F. L. Gilbert and C. A. Steers. 1975. Soil Associations of Alabama. Auburn Univ. (Alabama) Agr. Exp. Sta., Agronomy and Soils Department Series No. 24.
- (5) Johnson, Bruce B., Larry Lerstraitz and James D. Greer. 1967. Farm Real Estate Market in Nebraska. Neb. Agri. Exp. Sta. Bull. 495, Univ. of Neb.
- (6) Laird, David T. and John L. Adrian. 1979. An Analysis of the Rural Land Market in the Limestone Soil Region of Alabama. Auburn Univ. (Alabama) Agri. Exp. Sta. Bull. 512.

- (7) Lanham, Ben T., Jr., J. H. Yeager and Ben F. Alvord. 1953. Alabama Agriculture, Its Characteristics and Farming Areas. Auburn Univ. (Alabama) Agri. Exp. Sta. Bull. 283.
- (8) Mandale, Maurice and Philip M. Raup. 1974. The Minnesota Rural Real Estate Market in 1973. Univ. of Minn. Ec. Rpt. 74-1.
- (9) Nelson, W. E. and J. L. Adrian. 1976. Variations in Rural Land Values in the Black Belt Region of Alabama. Auburn Univ. (Alabama) Agri. Exp. Sta. Bull. 483.
- (10) Spurlock, S. R. and J. L. Adrian. 1978. Variations in Rural Land Values in the Wiregrass Region of Alabama. Auburn Univ. (Alabama) Agri. Exp. Sta. Bull. 504.
- (11) USDA, ESCS, NEAD. Farm Real Estate Market Developments. Washington, D.C.
- (12) Wise, James O., H. Jackson Dover and Bill R. Miller. 1972. Factors Affecting the Value of Rural Property in North Georgia. Ga. Agri. Exp. Sta. Bull. 103.

NOTES

NOTES

NOTES

THE JOURNAL
OF THE
ALABAMA ACADEMY
OF SCIENCE

AFFILIATED WITH THE
AMERICAN ASSOCIATION FOR THE
ADVANCEMENT OF SCIENCE

VOLUME 51

JULY, 1980

NO. 3

EDITOR:

W. H. Mason, General Biology, Auburn University, AL 36849

ARCHIVIST:

R. G. Eaves, Department of History, Auburn University, AL 36849

EDITORIAL BOARD:

R. T. Gudauskas, Chairman, Department of Botany and Microbiology, Auburn University, AL 36849

E. A. Curl, Department of Botany and Microbiology, Auburn University, AL 36849

W. W. Paulder, Department of Chemistry, University of Alabama, University, AL 35486

ADVISORY BOARD:

W. L. Alford, Auburn University

Charles Baugh, Univ. of South Alabama

G. F. Brockman, Univ. Ala., B'ham

R. J. Fornaro, Univ. South Alabama

A. Wayne Lacy, Auburn Univ., Mtgy.

Walker H. Land, Jr., IBM

H. S. Marks, N. E. St. Jr. Col.

M. Miller, Univ. South Alabama

W. W. Paulder, UA, Tuscaloosa

Dan Whitson, Decatur

E. M. Wilson, Univ. South Alabama

The Journal is the official publication of the Alabama Academy of Science, and is indexed in Biological Abstracts, Chemical Abstracts, America: History and Life, and Historical Abstracts.

Publication and Subscription Policies

Submission of Manuscripts. Submit all manuscripts and pertinent correspondence to the EDITOR. Each manuscript will receive two simultaneous reviews. For style details, follow Instruction to Authors, J. Ala. Acad. Sci. 50:96-97, 1979.

Reprints: Requests for reprints must be addressed to authors.

Subscriptions and Journal Exchanges: Address all correspondence to the CHAIRMAN OF THE EDITORIAL BOARD.

Advertising, News Releases: Advertisements and news releases will not be published in the Journal.

ISSN 002-4112

CONTENTS

KEYNOTE ADDRESS	164
---------------------------	-----

ABSTRACTS

Biological Sciences	175
Chemistry	195
Geology	201
Forestry, Geography, and Conservation	203
Physics and Mathematics	206
Industry and Economics	209
Science Education	212
Social Sciences	213
Health Sciences	217
Engineering	239

MINUTES OF ANNUAL BUSINESS MEETING	243
--	-----

ARTICLES

Gel Electrophoresis of Sonicated Virions of Two Nuclear Polyhedrosis Viruses Shiva P. Singh, Robert T. Gudauskas, and James D. Harper	249
Lateral Orange Coloration in Female <i>Sceloporus undulatus</i> : Variability and Refractoriness to Ovarian Steroids William E. Cooper, Jr. and C. Lynn Garthright	256

KEYNOTE ADDRESS¹

DRUG USE, ABUSE AND CONTROL
DR. EDWARD C. TOCUS²
ALABAMA ACADEMY OF SCIENCE
BIRMINGHAM, ALABAMA
MARCH 21, 1980

HISTORY AND LAWS

No one can date the origin of the first use of drugs by man. It is generally believed that primitive man considered disease as a supernatural process, perhaps caused by the presence of evil spirits as a punishment for wrong doing or an evil spell. We believe treatment consisted of attempts to drive out, or appease spirits. Prayers, incantations, spells, sacrifices, charms, magic, and special concoctions of herbs and animal parts were prepared and delivered to the ailing man by herb doctors, priest-healers, medicine men, etc. By trial and error, the inclusion of certain plants resulted in some relief of symptoms. These successful remedies were passed on to the following generations as part of the religious-medical folk culture. By the same process of trial and error, certain plants and infected animals were found to produce illness or death when taken by man. When these materials were recognized as toxic, their use was often forbidden by religious law. Thus, the first regulations evolved to control those foods and drugs which are both beneficial and harmful to society. These primitive regulations grew out of the experiences of early man in attempts to survive in a hostile environment.

One of the earliest written records of medical knowledge in ancient times is the Ebers Papyrus. This papyrus, although written about 1550 B.C. is really a collection of folk lore which dates from dynasties five to twenty centuries earlier. It is made up mainly of prescriptions for specified ailments; the substances to be used, their quantity, and the method of prescribing are included. Spells and incantations to be spoken during the preparation or the taking of the remedy are frequently interspersed. The 811 prescriptions are in the form of salves, plasters, poultices, snuffs, inhalations, gargles, draughts, confections, pills, fumigations, suppositories, enemata. A few prescriptions are simple, containing only one ingredient. The majority, however, are more complex, containing six to twelve or more materials, with one prescription containing thirty-seven ingredients. Part of the directions indicate where and when the materials used were to be gathered and the manner in which

¹Presented at the annual banquet of the Alabama Academy of Science.

²Dr. Tocus is Chief of the Drug Abuse Staff of the Division of Neuropharmacological Drug Products, Bureau of Drugs, Public Health Service, Food and Drug Administration, Rockville, Maryland 20857.

they were to be taken, for example: one woman was ordered to take her medicine while she sat cross-legged.

Of the plants tried to treat primitive illness, most certainly those which affected the mind and those which reduced pain would have been recognized. Drugs which have a short onset of action after oral administration would have been particularly recognized by primitive man. Thus we are not surprised to find, among the earliest written records of man, references to opium and hashish. In 2737 B.C., Emperor Shen Nung of China recommended marijuana for several ailments including gout, constipation, and absent-mindedness. Alcohol was apparently known to primitive man, and references to wine appear in earliest recorded history. Because fermentation of the sugar in fruit is a process which can occur in nature, it is not surprising that ancient man discovered this property of fermented fruit. Wine became a vehicle for the preparation of materials for treatment. It was undoubtedly used as a drink.

The use of mind-altering drugs was practiced by the native Americans before the discovery of the New World. Amerigo Vespucci observed the natives of Margarita Island, off the coast of Venezuela, chewing a green herb which historians report to have been coca leaves. Christopher Columbus, during his second voyage 1493-1496, observed the use of *cohoba* snuff by the West Indian natives (Efron, 2967). Immigrants to the New World brought alcohol, coffee, and tea. Coffee and tobacco were grown in the colonies; however, tea was imported. The issue of importation of tea is one of the factors in colonial history which led to the American Revolution. Settlers from various countries introduced their favorite alcoholic beverages and developed the capacity to produce them. Inns and taverns which served beer, ale, and various whiskeys became a meeting place for much of early American society. This tradition continued throughout American cultural history (Barck and Leffler, 2968).

The use of alcoholic beverages, tobacco and tea has been accepted by the American society and continues to be those substances for recreational use that have a detrimental effect on individuals in our society.

There *are* substances which our society feels are harmful to the individual which have led to the passing of laws to prevent their distribution to the society as a whole. In addition, it has been recognized that unless certain standards are maintained for the processing and storing of food substances, deterioration or decay may set in which can also be harmful to individuals within our society. The State of Massachusetts enacted the first general food law in the United States in 1784. The first drug law was passed in 1848 when quinine used by the American troops in Mexico to treat malaria was found to be adulterated. The Federal Government passed the Import Drug Act to insure the quality of quinine. Between 1891 and 1895, a number of acts were passed which required inspection of animals for disease before slaughter, in order to prevent the passage of disease into the food chain. On June 30, 1906 the original Food and Drug Act was passed and signed by President Theodore Roosevelt. This Act regulated interstate commerce in misbranded and adulterated foods, drinks and drugs. The Meat Inspection Act was passed the same day. These Acts followed disclosures of unsanitary

conditions in meat packing plants, use of poisonous preservatives and dyes in foods, and a widespread occurrence of cure-all claims for worthless and dangerous patent medicines at that time. In 1927, a separate law enforcement agency was formed which was originally known as the Food, Drug and Insecticides Administration and then, in 1931, as the Food and Drug Administration, the FDA. In 1938, the Federal, Food, Drug and Cosmetic Act was passed and contained a number of new provisions which were:

1. Extended coverage to include cosmetics and devices
2. A requirement for pre-distribution clearance of safety on new drugs
3. Elimination of a previous requirement to prove intent to defraud in drug misbranding cases
4. A provision for tolerances for unavoidable or required poisonous substances
5. Authorized standards of identity, quality and fill of container for foods
6. It authorized factory inspections, and
7. Provided for a court injunction for seizure of substances, and prosecution for violation.

In 1962, the Food, Drug and Cosmetic Act was amended to require for the first time, that drug manufacturers prove to the FDA the effectiveness of their products before marketing. Thus, the people through their Congress, have passed laws to provide for the safety and effectiveness of drugs which are offered for therapeutic indications and treatment in the United States.

At the same time concern was being expressed over foods and drugs consumed by the American population, there also was concern over the consumption of substances which produced addiction, or dependence. In 1887 the United States passed one of the first laws directed against drug abuse. This Act prohibited importation of opium into the United States. In August of 1903, a U.S. opium commission was established to study methods of regulation and control of opium in countries where opium was used. In spite of the laws which existed, the use of opium for smoking continued to increase, and according to the opium commissioner, over 160,000 pounds of opium were imported for smoking and eating in the year 1907. In addition to opium, other addicting drugs were being imported. In 1906, 2,600,000 pounds of coca leaves were imported into the United States. The drug abuse problem continued to grow as indicated by an article which appeared in the New York Times on March 15, 1911: "It is not pleasant to be told, as Mr. Hamilton Wright, Federal Opium Commissioner has told us, that 'Uncle Sam is the worst drug fiend in the world, consuming yearly more opium than China or any other nation. The United States uses 500,000 pounds annually in one form or another, a hundred-fold more than is prescribed by physicians. Mr. Wright judges that 'at least one druggist out of 10 exists by means of profits from the sale of habit-forming drugs of which, of course, opium and its derivatives are most important.'" On December 17, 1914, President Woodrow Wilson signed the Federal Narcotic Internal Revenue Regulations, commonly called the Harrison Narcotic Act. This Act was a milestone in federal control of narcotics and regulated activities within the United States for 55 years.

With the exception of the attempted prohibition of alcohol in the 30's, the problems with abuse of drugs remained relatively stable until the decade of the 1960's which brought a significant increase in drug abuse. The causes of this increase are highly complex, but probably related to other events taking place in the United States. One factor may be that the children of veterans of World War II were between the ages of 15 to 25 years old, and were a rather unique population. It was also during this time, when the Vietnamese War became unpopular and anxieties concerning that war were great. Another important change was the rise of a social conscience which demanded changing attitudes toward social values and other social institutions. Whereas drug problems until this time were confined primarily to the narcotics and marijuana, with the 1960's, an entire armamentarium of psychotropic drugs entered the illicit market. Dr. Timothy Leary, a former Harvard University psychologist, gave the drug movement additional momentum by forming the league for spiritual discovery, commonly called LSD, which also stands for the drug lysergic acid diethylamide. The motto of Dr. Leary's league was coined in the phrase "turn on, tune in, and drop out." With these words and with the additional new drugs, the drug cult exploded. Amphetamine, methamphetamine, glue and various solvents, LSD, barbiturates, marijuana, and a host of marketed tranquilizers became attractive and widely used. With an increase in the use of more or less exotic drugs, there was also an increase in heroin use.

In 1965, as a response to the illicit drug use, Congress passed the Drug Abuse Control Amendments to the Food, Drug and Cosmetic Act. The law allowed the FDA to require all legal handlers of drugs subject to control under various laws to keep records of their supplies and sales and, in addition, to seize illegal supplies of controlled drugs, to serve warrants and to arrest violaters. The FDA established at that time a Bureau of Drug Abuse Control in order to implement provisions of the new Act. In 1968, under a reorganization plan, the Bureau of Drug Abuse Control of the FDA, and the Bureau of Narcotics of the Treasury Department, were merged to form the Bureau of Narcotics and Dangerous Drugs in the Department of Justice. Congress then brought into one single law, provisions of a number of laws which had been passed through the years to attempt to control the drug abuse problem. It was in 1970 that the Comprehensive Drug Abuse Prevention and Control Act was enacted. This Act signalled the end of the Harrison Narcotic Act which had been enforced during the entire previous 55 years. The Federal Government has been implementing provisions of the Comprehensive Drug Abuse Prevention and Control Act known as the Controlled Substances Act, for the past ten years. So much for the history of the laws and acts which have been promulgated to attempt to protect the people of the United States from adulterated and harmful food, drugs and other substances.

PEOPLE

What is it about people which leads them to take drugs in ways other than as prescribed for therapeutic purposes? There are five basic reasons for taking drugs for non-therapeutic purposes which will be briefly discussed. These are:

1. Accidental non-therapeutic use and intentional overdose (suicide).
2. In response to social pressure.
3. For the pleasure the substance gives.
4. As a result of curiosity about the substance.
5. In an attempt at self-medication.

Accidental non-therapeutic drug use occurs often among the very young and in children. This type of drug-taking is not generally included in a definition of abuse of drugs. However, when drugs are taken deliberately, as a means of suicide, or where death occurs accidentally from overdoses outside of the therapeutic intention, such use is considered drug abuse. When a consideration is made of the abuse liability of a drug, the toxicity of the substance is considered with respect to its potential for causing death from overdose or suicide. For example, a single prescription of a barbiturate sedative-hypnotic can contain a lethal dose if the entire bottle is taken. A single prescription of a benzodiazepine sedative-hypnotic, probably does not contain a lethal dose. Therefore, when we compare the probability of suicide in the two classes of sedative-hypnotic drugs, we conclude that the barbiturates have a higher potential for producing death than do the benzodiazepines and, therefore, have a higher abuse liability. This property is reflected in the status of the benzodiazepines relative to the barbiturate sedative hypnotics under the Controlled Substances Act. The barbiturates are controlled in a much more restrictive manner than are the benzodiazepines.

A second reason drugs are taken is in response to social pressure. Almost from the time of birth, an individual is taught to conform. Certain behavior is positively reinforced while other behavior is negatively reinforced by the family unit. Thus, a child is taught to behave along certain patterns which the parents have established as acceptable. As the children grow, they are exposed to other children of similar age in the neighborhood. Children become aware of belonging to a group other than the immediate family group. The need to conform to a peer group occurs very early in childhood, this need is utilized in the advertising of toys. Those of you who are parents have experienced arguments that because another child has certain items, your child also must have the same items. This peer pressure can interfere in behavioral patterns established by the family as being acceptable, and produce behavior which the family has established as being unacceptable. As our children grow, they become more aware of themselves as individuals and follow a natural tendency for expression as individuals. The conflicts and pressures thus created can act on children so that their behavior moves in the direction of conformity to their peers in areas that reinforce feelings of individuality within the family. Such behavior, for example, is very often exhibited in the initiation of cigarette smoking. By this single act, the juvenile can express conformity with a peer group, rebellion towards the family, and performance of an act perceived as adult which reinforces the feeling of individual accomplishment. The same can be said for drinking alcohol and beer at an early age. Unfortunately, both cigarette smoking and the drinking of alcohol produce a drug (pharmacological) reinforcement of activity which leads to a degree of physical

and psychological dependence. Unless this activity can be interrupted at an early age, it can lead to continuous and habit-forming behavior which can be detrimental to the health of that individual. The peer pressure which leads to this type of drug-taking behavior can be very powerful. It can, and has, disrupted the family influence over individual children and has led to the dissociation of the child from the family. It can be a lack of understanding of this peer pressure which causes the family members to react negatively to the drug-taking behavior. Thus, rather than offering an alternative which the child can accept which reinforces a position as a family member, the child is negatively reinforced by the family and turns even more strongly to the peer group activities which are now more comfortable. Thus, the social influence on youth and, indeed, on adults can lead to drug-seeking behavior because of the desire to conform to group behavior.

Another reason people take drugs for non-therapeutic purposes is for pleasure. Many of the centrally acting drugs and many of the substances which are used for non-therapeutic purposes, but are not marketed as therapeutic entities, produce effects which a significant portion of our population would consider as pleasurable. There are people who feel the need of a drug in order to become sociable. The cocktail party, the drink before dinner, the general feeling that until the second round of drinks a party has not started is widespread in our society today. Today's youth knows well the use of alcohol by the adult population in our culture. The youth have taken this behavior model and extended it to their own generation to include the use of substances other than alcohol, essentially for the same purpose. The outcome and the motive are the same, namely, to become more sociable and to experience pleasure.

A fourth motivation of drug-taking is natural curiosity about what will happen or what one will experience after taking the drug. This experimentation has become directed to the drug field as a natural sequel to the increased numbers of CNS-active drugs which have been produced. I have been told that one of the most popular books in the New York Public Library is the Physician's Desk Reference, the PDR. I understand the loan period for this particular book is in terms of minutes, rather than days, because the book is so popular. It would be interesting to determine the characteristics of the population which selects the PDR from the New York Public Library and the purposes for which they obtain information from this book. I would guess there are two general classes looking for information in the PDR. The first would be those people who have been prescribed a drug by their doctor for some condition about which they are totally unknowledgeable. People are increasingly curious about what to expect from the drugs which they are given. The fact that the PDR contains the package insert material from a number of currently marketed prescription drugs is common knowledge and this would be a likely source for individuals seeking information about drugs they are taking. It is for this reason that we at the FDA believe that some drugs should have a patient package insert with information which would be useful to the patient and might, perhaps, benefit the intended therapy through improved understanding of the proper use of the drug.

The second group of persons seeking the PDR, I would guess to be those who are obtaining drugs illicitly or are searching for drugs in order to experiment with their pharmacological effects. These people may be searching for the maximum tolerated dose, or looking under general classifications such as sedative hypnotics, or tranquilizers. For whatever reason, mankind continues to experiment and to explore with drugs, foods, and other substances to determine what effects might occur.

Still another reason for drug use is self-medication, when people seek to modify or amplify a behavior which they have already established. Thus, artists may want to enhance their perception and explore the use of various substances reported to modify visual or auditory stimuli. Other individuals, experienced in meditation, may wish to obtain a state of relaxation to facilitate meditation and self-awareness. Another aspect of self-medication is seen when a prescribed drug is used beyond its indication. Certainly drugs are taken in cases where tension occurs, and individuals wish to relax. In cases of a mild depression, individuals may take drugs for purposes of stimulation in order to cope with their environment. In such instances, the individuals are taking the drug for its pharmacological effect; however, the drug is being taken without the benefit of a proper diagnosis, prescription and monitoring of the results by a physician.

DRUG

Those are some of the factors within individuals causing them to seek and take drugs other than as prescribed by physicians for recognized and approved therapeutic indications. The other half of the equation of non-therapeutic drug use relates to the properties of drugs which cause them to be sought by individuals for their effects on the central nervous system. The effects we will be discussing are those that are perceived by the individual taking the drug. This limitation of effect is necessary because there are two elements to the drug activity: (1) the response which the drug is capable of eliciting and (2) the interpretation of that response by the individual. This interpretation can be the awareness of satisfaction for some need, some feeling, or mood change which is considered to be pleasant and to be sought, or as being unpleasant and to be avoided. It is this interpretation of a drug activity which makes the determination of a potential for abuse of a drug difficult to predict from purely pharmacological studies.

We generally classify psychoactive drugs into four (4) broad categories which are: narcotics, stimulants, depressants and hallucinogenics. The term narcotic is a legal term; however, we generally will mean opiate-like when using the term narcotic. The narcotic drugs generally have an analgesic activity and have the ability to block the perception of pain. In an individual suffering from severe pain, the relief of pain alone is sufficient to cause that individual to want to continue taking the drug. In addition, the opiates have a euphorigenic component which is perceived by some individuals as a pleasurable experience. This feeling is transitory and followed by the state of narcosis which also is perceived as being pleasant and desirable by some

individuals. The opiates can produce both a physical dependence and a psychological dependence. Physical dependence can be characterized by the production of motor and autonomic responses when the drug is withdrawn, which we term "withdrawal syndrome."

Psychological dependence can be considered the effects of the drug which cause the individual to develop an extreme craving for the substance. We have been able to overcome the physical dependence problem associated with the opiates in that we can detoxify and minimize the physiological withdrawal syndrome. We have been unable to overcome the psychological dependence however, so that although individuals no longer suffer the physical withdrawal syndrome when they are without an opiate, the craving becomes overwhelming and they will seek and take the drug for non-therapeutic purposes.

The depressants are those drugs which cause a decrease in the physiological and/or the mental activity of an individual. Thus, the sedative-hypnotics, analgesics, tranquilizers, some antihistamines, alcohol and such drugs are depressants. As with most drugs, the response to the depressants is dose-dependent. At low doses, there is little activity on the motor cortex of the brain; however, the sensory pathways are mildly inhibited so that some external stimuli tend to be blocked. This causes a certain disinhibition of thoughts and feelings, the individual becomes relaxed and somewhat more lively, which is what normally is referred to as the stimulant action of alcohol and other such drugs. As the dose of depressants increases, impulses to the motor cortex begin to be inhibited leading to a greater degree of relaxation which, if continued, leads to incoordination of motor function. Thus, an individual can achieve a level of dissociation from environmental stimuli based on the dose of depressant which he chooses to take.

Stimulants are drugs which have an activity opposite from that of the depressants. We must separate though, drugs which are stimulants from drugs which are classified as antidepressants. Antidepressants generally have no stimulating action of their own, and may even in normal individuals act as mild sedatives. They generally have a slow onset of action, and it may take days before their maximum effects are recognized. This class of antidepressants includes drugs such as imipramine, amitriptyline and other tricyclic compounds which have not played a role in the drug abuse field to any significant degree. On the other hand, we have drugs, such as cocaine, amphetamine and methamphetamine, which are classified as stimulants. These drugs are significant in the drug abuse field. They generally are characterized by a rapid onset of action and a state of wakefulness and alertness. Thus, the stimulants can produce a sense of exhilaration and ability to cope with the environment which otherwise would not be felt. As with depressants, the activity of the stimulants is dose-dependent. With small doses, the feeling can be one of heightened awareness to environmental stimuli; there is an increase in heart rate and a generalized ability to handle external stimuli quickly and effectively. As the dose increases, the sensory input to the brain also increases to some point at which assimilation of this information can no longer be adequately handled, and the individual begins to misinterpret what he perceives. At this point, thoughts may

become very rapid and jump from one idea to the other. The motor system is overstimulated such that the individual is physically jumpy and what we might call "hyper." Thus, with increasing doses, the individual approaches a psychological state which appears similar to that of a manic psychosis and at times the behavior can be mistaken for paranoid schizophrenia. These states result from the misinterpretation of external stimuli. Thus, an individual who seeks certain mood states can achieve the desired effect through use of the stimulants, according to the dose administered, as he could through the use of depressants.

The fourth class of drugs is the hallucinogenics. This class of drugs has the capacity to distort stimuli arising either externally or internally, and has no recognized medical indications. We know less about the hallucinogenics than we do about the other classes of drugs. The brain has a capacity for discriminating stimuli, eliminating those of little significance, and integrating those of immediate consequence such that the individual perceives the environment as reality. The hallucinogenics somehow affect the capacity of the individual to discriminate and integrate stimuli which results in a distortion of what otherwise would be reality of the environment. Thus, hallucinogenics can distort visual images by changing shape and colors, can distort auditory stimuli, such that sounds are amplified, created, or misinterpreted. The thought process may also be distorted in that the individual creates illusions of feelings and sensations which otherwise would not occur. Of all the drugs of abuse, it is the hallucinogenics which produce an effect more related toward characteristics of a particular individual than would be predicted by any of the other classes of drugs. It is for this reason that a single drug can produce extremes of response and experiences from one individual to another. To some people these may be desirable, beautiful, exhilarating, etc. To others, they may be frightening or horrifying, such that the person will destroy himself in an attempt to escape. Thus, while the depressants, stimulants and narcotics are generally used to modify environmental stimuli, the hallucinogenics are used to dissociate oneself from the environment and create new stimuli for that individual.

We have seen some of the reasons individuals may take drugs and other substances for non-therapeutic purposes. For whatever reason, society has the tendency to place value judgments on these drug-taking behaviors and to relate some as acceptable and others as non-acceptable. It is these value judgments which are translated into laws and it is these laws that the Executive Branch of government is charged with carrying out.

GOVERNMENT

Three agencies of the Federal Government have primary responsibility in the area of drug abuse. The Drug Enforcement Administration, previously the Bureau of Narcotics and Dangerous Drugs, is responsible for enforcement activities with respect to illicit and clandestinely manufactured substances. The Drug Enforcement Administration (DEA) is the lead agency for enforcing the Controlled Substances Act. It is the responsibility of the DEA to place drugs under the Controlled Substances

Act. It is the DEA that determines the manufacturing quotas for drugs controlled under certain provisions of the Controlled Substances Act. The DEA is responsible for registration of physicians who wish to prescribe controlled substances; for industry that wishes to manufacture or distribute controlled substances; and for regulating the importation and exportation of controlled substances. The Drug Enforcement Administration has agents throughout the United States and in various countries to determine the clandestine use of drugs and other substances. These agents buy the materials and have them analyzed by DEA laboratories. The DEA gathers data, makes arrests, and brings these arrested individuals to court for their illicit drug activities. The major function for the Drug Enforcement Administration is to limit the supply of illicit drugs which are available for use in the general population.

The Department of Health, Education and Welfare is responsible for the medical and scientific aspects of the drug abuse problem. Within HEW there is the Alcohol, Drug Abuse and Mental Health Administration known by the acronym A.D.A.M.H.A. or ADAMHA. The National Institute on Alcohol and Alcoholism functions separately from the other agencies concerned with the drug abuse problem. The Controlled Substances Act, in defining a controlled substance, states "the term does not include distilled spirits, wine, malt beverages or bobacco, as those terms are defined or used in sub-title "E" of the Internal Revenue Code of 1954." Thus, alcohol and tobacco are available to the general public and taxed under the Internal Revenue system. The National Institute on Alcohol and Alcoholism is functioning under laws separate from the Controlled Substances Act. The National Institute on Drug Abuse is responsible for information relative to the drug abuse problem and for funding community assistance programs for such problems in the United States. The Food and Drug Administration is the regulatory agency with all drugs. In the area of drug abuse the FDA has been delegated certain responsibilities by the Secretary of H.E.W. The Controlled Substances Act states that the Secretary shall evaluate data gathered on the abuse of drugs and substances on the basis of which the Secretary makes recommendations to DEA in the Department of Justice with respect to whether or not the substance should be controlled. The law provides for five (5) schedules for drugs with the first being most restrictive and carrying the most severe penalties for violations. Schedules II, III and IV become progressively less restrictive with Schedule V for least restricted drugs, such as non-prescription cough preparations. The Act requires that results of studies and investigations of the quantities of narcotic drugs or other drugs, subject to quota restrictions under the Controlled Substances Act, along with reserves of such drugs that are necessary to supply the normal and emergency medical and scientific requirements of the United States shall be reported not later than the 1st of April of each year to the Attorney General for use in determining manufacturing quotas for such substances. This means that H.E.W. estimates the amount of a substance necessary so that the medical and scientific needs of the United States will not be overly restricted by way of controls. However, the Department of Justice determines the total amount of substance which may be manufactured and the amount allocated to each pharmaceutical manufacturer for that particular substance. The Controlled Substances Act requires a separate registration for research with *Schedule I* substances, such as heroin

Keynote Address

and marijuana. This registration requires a determination of qualifications and competency of the practitioner and an evaluation of the research protocol. The Department of Justice determines whether or not the individual has adequate safeguards to prevent diversion of the Schedule I substance. However, the applicants are evaluated for qualifications and scientific merit by FDA for HEW. Thus, all applications for registration for Schedule I substances for research are approved by FDA. In addition, applications for clinical studies for Schedule I substances (none of which are marketed) must also come under the IND Investigational New Drug Application provisions of the Food, Drug and Cosmetic Act. Thus, for research for Schedule I substances, the approval for both registration and clinical studies resides in this same group at the FDA. We try to expedite the registration applications for researchers who have made application for Investigational New Drugs (INDs). Since most clinical studies in the area of drug abuse are directed toward determining whether there is a potential public health risk from the illicit use of the substance, or to determine a therapeutic treatment of a condition caused by illicit drug use, we believe it is desirable to facilitate research with Schedule I substances. In addition, there may be therapeutic indications for substances controlled under schedule I unrelated to the abuse liability or illicit use of that substance. This is the case with the tetrahydrocannabinols. Delta-9-tetrahydrocannabinol (THC) is the active ingredient obtained in pure form from the cannabis plant. There has been much publicity concerning the investigation of THC for the treatment of increased intraocular pressure of open-angle glaucoma. Additionally, there have been several studies of the effects of THC in preventing nausea and vomiting associated with chemotherapy in the cancer treatment programs. THC is, therefore, the prototype for a class of compounds which may have therapeutic application in the practice of medicine. It is necessary that studies be allowed in order to continue the development of synthetic cannabinoids which may be more specific in their activity without the central effects associated with THC and cannabis. Thus, FDA attempts to minimize the harm to the public health from substances which are used illicitly, at the same time allowing legitimate use to continue whether in research or treatment.

The development of drugs for therapeutic purposes has been a significant factor in improving health and prolonging life in all the people. When drugs are used for recreational and non-therapeutic purposes they can be harmful and destructive. We are working to reduce the destructive use of drugs by reducing the supply and the demand. Ultimately the individual must decide to refuse the pressures toward non-therapeutic drug use. We hope humanity will eventually mature enough to eliminate the need for our present concern for the abuse of drugs.

Thank you for the privilege of speaking this evening.

ABSTRACTS

Papers Presented at the 57th Annual Meeting
Samford University
Birmingham, Alabama
March 20-22, 1980

BIOLOGICAL SCIENCES

INTROGRESSING TREEFROGS: AN ACOUSTICAL-MORPHOLOGICAL STUDY

Ellen Schlefer. Dept. of Biology, Tuskegee Inst., Tuskegee, AL 36088.

Introgression of two species of treefrogs, *Hyla cinerea* and *Hyla gratiosa*, identified by Mecham (1960) at the Auburn Fishery Research Ponds was reassessed by morphological and acoustical analysis. The best separation of the hybrids from parental species using both acoustical and morphological measurements was achieved by a headwidth to tibio-fibula ratio and low frequency peak plot. Using these criteria on a small sample size (13), eight recorded hybrids were distinguished from individuals of parental populations. Hybrids have been unequivocally distinguished from *H. cinerea* and *H. gratiosa* by using the headwidth: tibio-fibula ratio (Gerhardt, personal communications). Using only this ratio on a larger sample (90) from the Auburn Fishery Research Pond population, introgression was indicated by the continuum of measurements. Harmonic structure of the hybrid calls corresponded to *H. gratiosa*-like and *H. cinerea*-like call types previously identified. Of the eight recorded hybrids, four had a *cinerea*-like and four a *gratiosa*-like call. This research was funded by a National Science Foundation Minority Institution Graduate Traineeship.

OÖGENESIS IN THE BANDED SCULPIN, *COTTUS CAROLINAE*

Jim Shaner and Charles E. Keys. Dept. of Biology, Univ. of N. Ala., Florence, AL 35630.

The seasonal changes in the ovary of *Cottus carolinæ* are observed during a twelve month period. Development takes place with a smooth transition from one season to the next, however distinct seasonal characters are observed. Early development results in growth of the nucleus and cytoplasmic region while later development is characterized by accumulation of yolk. Early vitellogenesis is observed in oocytes which have an approximate size of 275 microns. With the onset of vitellogenesis growth of the egg is immense due to the accumulation of yolk and results in mature eggs that are approximately 2500 microns in size.

Abstracts

ESTROGENS WITH THE EQUIVALENT RECEPTOR ASSOCIATION CONSTANTS DO NOT ALWAYS PRODUCE EQUIVALENT UTERINE RESPONSES EVEN AT EQUIVALENT DOSAGE

P. S. Campbell, G. A. Newman, G. C. Loveless, and H. J. Wilson. Dept. of Biology, Univ. of Ala. at Huntsville, Huntsville, AL 35807.

The effects of the naturally occurring steroid estradiol-17 β (E) and the synthetic, nonsteroidal estrogen diethylstilbestrol (DES) upon various uterine parameters were studied in relationship to the temporal pattern of nuclear retention of the receptor-estrogen complex (REC) for each hormone. True uterine growth was stimulated to a greater extent by DES than E and was paralleled by augmented nuclear retention of the DES-REC. The percent difference in the growth response to the two different estrogens exhibited a close numerical correspondence to the percent difference in nuclear REC retention. The effect of the two hormones upon uterine isometric tension development and nuclear retention of REC was qualitatively and quantitatively similar to the uterotrophic response. The greater contractile response to DES was associated with significantly greater actomyosin production. In contrast, DES was much less potent than E in stimulating uterine fluid imbibition and glucose oxidation. Furthermore, no apparent causal relationship between nuclear REC and these parameters was noted. It is suggested that water imbibition may not be obligatorily coupled to nuclear REC interactions as currently thought and that membrane interactions and/or uterine blood flow may be more important. Availability of oxidized coenzyme may be the limiting factor in the reduced sensitivity of uterine glucose oxidation to DES stimulation.

STUDIES ON THE NUCLEAR TRANSLOCATION OF THE ESTROGEN-RECEPTOR COMPLEX

C. W. Albright, P. S. Campbell, and H. J. Wilson. Dept. of Biology, Univ. of Ala. at Huntsville, Huntsville, AL 35807.

The effects of calcium chelating agents, calcium substitution, anti-microfilamentous/antimicrotubular drugs, microtubular stabilizing agents, and temperature upon nuclear translocation of the receptor-estrogen complex (REC) were studied in uterine tissue in an attempt to ascertain the mechanics of this process. The absence of available calcium in the incubation medium through use of chelating agents or choline substitution resulted in significant decreases in nuclear bound [^3H] estradiol. However, this impairment appeared to be more of an inhibitory effect upon cellular uptake of [^3H] estradiol than solely on translocation. Compounds that disrupt dynamic microtubule or microfilament action through rigid stabilization of structure or disassembly had negligible effects upon the translocation process when used singly or in a number of different combinations. One particular type of combination, though, was efficacious in producing a substantial reduction in nuclear REC in the absence of any apparent reduction in cellular uptake of [^3H] estradiol. Only the combined regimens involving two compounds with disparate effects upon microtubular systems were effective in largely inhibiting

Abstracts

translocation (*i.e.*, an antimicrotubular drug in the presence of a microtubular stabilizing agent). The effect of temperature upon the compartmentalization of bound [^3H] estradiol between the cytoplasmic and nuclear regions gave a Q_{10} coefficient suggesting translocation to be a biological rather than physical (diffusion) event.

MARKER ENZYME ACTIVITIES OF CELL COMPONENTS OF GILL TISSUE OF THE STRIPED MULLET (*MUGIL CEPHALUS*) FOLLOWING FRACTIONATION AND PURIFICATION IN SUCROSE DENSITY GRADIENTS

Eric Black and George B. Cline. Dept. of Biology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Sodium regulation in the face of higher salinities is due to the cellular synthesis of more $\text{Na}^+\text{-K}^+$ ATPase or to greater usage of what is present in the gills. One approach to determining this is to fractionate the gill tissue from fish adapted to different salinities by high resolution cell fractionation procedures and to assay the cellular components. Five to 10 grams of gill tissue of the mullet was removed by dissection, and sonicated in 20mM imidazole buffer, pH 7.4 for a single 3 minute period at 65 watts/cm². The sonicate was centrifuged at low speed to sediment cartilagenous material and 10 ml of the supernatant used as the starting sample for sucrose gradient fractionation. The 600 ml sucrose density gradient in the B-XIV zonal rotor was made up of 5 steps using the following % w/w sucrose solutions: 26, 37, 41, 47, 53 and 55. Separation took place during a 30 minute spin at 45,000 rpm. The gradient was monitored at 280 nm during unloading and was collected in 20 ml aliquots for further analysis. Vesicular forms of the plasma membrane were separated from the sheet forms. The mitochondrial fraction was banded at approximately 43% while rough endoplasmic reticulum was collected at about 51% sucrose. $\text{Na}^+\text{-K}^+$ ATPase activity is being used to locate the plasma membrane fractions, cytochrome oxidase as the marker for the mitochondrial fraction and 5' nucleotidase activity for both the plasma membrane and the Golgi.

ION REGULATION BY THE GILL MEMBRANES OF THE STRIPED MULLET (*MUGIL CEPHALUS*) AS MEASURED BY PERFUSION STUDIES

Eric Black, Richard L. Shoemaker, and George B. Cline, Dept. of Biology and Dept. of Physiology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

An apparatus which permits the easy perfusion of gills in intact fish heads has been built and tested. Ion regulation by gill membranes can be studied by varying either the internal (blood) ion concentrations or the external (sea water) ion concentrations. Initial studies show that gill tissue of the striped mullet can regulate several ions when challenged with sea water of high ionic strength. When exposed to sea water containing (in meq/l); 410 sodium, 9.09 potassium and 458 chloride, the gills maintained an internal concentration of 142, 4.09, and 117 respectively. When the external ion concentrations are increased to 551,

12.76 and 628, the gills still regulate to 142.6, 4.11 and 118. The apparatus will be used to "set" ion regulation before isolating gill tissue for enzyme studies on fractionated and purified subcellular components.

CHEMICAL COMPOSITION AND CELLS OF THE HEMOLYMPH OF THE SLIPPER LOBSTER (*SCYLLARIDES NODIFER*)

George B. Cline, Dept. of Biology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

There are few biological data on the slipper lobster. A first approach to understanding this animal is to analyze its body fluids for cell types, concentrations and functions and its fluids and tissues for proteins and other gene products. This lobster can be kept conveniently for long periods of time and over several yearly molts. One ml of hemolymph can be collected daily from the dorsal sinus but animals kept at 16°C may be seriously depleted of both cells and proteins by more than 10 consecutive withdrawals. One animal had about 300 hemocytes per mm³. Cells varied from large granular hemocytes to the smaller plasmacytes. Hemolymph can be kept from clotting by using 1 part in 10 saturated sodium citrate, pH 7.6 or by using 1 part in 10 of 500 mM dithiothreitol. Analyses of hemolymph from fresh animals gave: 110 mg/dl calcium; 501 meq/l sodium; 8.9 meq/l potassium; 500 meq/l chloride; 2 mg/dl BUN (blood urea nitrogen); no detectable CO₂; no detectable glucose, and no detectable estrogen (1 female). Electrophoresis of cell-free lymph shows at least 4 classes of proteins, one of which has considerably faster electrophoretic mobility than rabbit albumin.

DETECTION AND DISTRIBUTION OF ISOENZYMES OF PHOSPHOGLUCOMUTASE BY FLUROSPECTROPHOTOMETRIC ASSAY OF ISOELECTRIC FOCUSED MUSCLE EXTRACTS OF THE SLIPPER LOBSTER (*SCYLLARIDES NODIFER*)

Herb Frith and George B. Cline, Dept. of Biology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The development of a sensitive approach for isozyme characterization in muscle tissue is presented. Phosphoglucomutase isozymes from white-muscle tissue extracts of the lobster, *Scyllarides nodifer*, are isolated by isoelectric focusing in thin-layer polyacrylamide gels. The gels are cut out into selected portions and the focused isozymes are allowed to diffuse into individual buffer solutions. Various reagents and cofactors are added to each to assay for PGM. The production of NADPH₂ by a coupled-enzyme reaction indicates PGM activity and is measured by an Aminco SPF-500 Spectrofluorometer at 460 nm for 5.0 min. The efficiency of NADPH₂ fluorescence in the system (0.033 units of fluorescence for one nanomole of NADPH₂ per milliliter of assay solution for NADPH₂ concentrations less than about 20 nmoles per ml) is determined to estimate the amount of PGM enzyme present. Analysis of two lobsters from the same general area show at least two PGM isozymes exist, whose pI values are 5.25-5.30 and 5.50-5.55.

Abstracts

VARIATION IN THE CHARACTERISTICS USED TO DISTINGUISH *OBOVARIA UNICOLOR* LEA FROM *OBOVARIA JACKSONIANA* FRIERSON

Michael A. Hoggarth and Paul Yokley, Jr. Dept. of Biology, Univ. of N. Ala., Florence, AL 35630.

Obovaria unicolor and *Obovaria jacksoniana* are difficult to distinguish using currently available taxonomic information. Variations in the shells result in character overlap between species. Differences between males and females of the same species become obscure as well. These variations have been investigated and the shell characteristics of the males, females and of each species described. The length to width and length to height ratios for *Obovaria unicolor* were found to be greater than the same ratios for *Obovaria jacksoniana*. Female shells of each species were found to be characteristically smaller than male shells and to have a height to height (perpendicular to the posterior end of the lateral teeth) ratio greater than for males. This characteristic results from the expanded posteroventral portion of the females' shell being enlarged as the demibranchs are gravid. Shell characteristics that may be more useful in the field are also discussed.

HYDROLOGIC EVENTS AND NUTRIENT INPUT TO AN ALABAMA STREAM

Michael Mullen, David L. Guernsey, and Richard F. Modlin. Dept. of Biology, Univ. of Ala. in Huntsville, Huntsville, AL 35807.

Sources of nutrient input to Indian Creek, Madison County, Alabama, and the influence of hydrologic events on the nutrient flux of this stream were examined. Non-point sources from a cow pasture were found to significantly influence only those areas of the stream located in the immediate vicinity of the nutrient input. This suggested that the nutrients were tied up in periphyton growth, adsorbed on the sediments, and diluted to a point that downstream nutrient concentrations were not detectably influenced by a cattle lot. Data were collected over a four-day period which included a rainstorm, and the stream rise and fall. Precipitation, stream stage, turbidity, orthophosphate, nitrate, and tannins and lignins were studied in relation to the various processes that occurred in the stream. Orthophosphate and tannin and lignin concentration changes with time showed a strong positive correlation with stream stage and turbidity. Nitrate concentrations showed strong negative correlations with both stream stage and turbidity.

BRAIN-OVARY INTERACTIONS IN THE HOUSE CRICKET

J. T. Bradley and T. A. Simpson, Jr. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

The pars intercerebralis (p.i.c.) region of the brain of the house cricket contains a group of about 600 neurosecretory cells (NSC) whose cytoplasm stains light blue to dark blue with paraldehyde fuchsin (PF). The axons of these NSC terminate in a neurohemal organ, the corpus

cardiacum (CC). The ultrastructure of neurosecretory granules (NSG) in the CC is indistinguishable from that of NSG in the cell bodies of the brain NSC. The histological state of the p.i.c. NSC has been assessed during the reproductive cycle of adult females and following ovariectomy using PF staining. The brain and CC are nearly empty of PF positive material 72 hours after adult ecdysis, corresponding to the initiation of vitellogenesis, whereas the brain and CC contain a maximum amount of PF positive material on day 10 of adult life, corresponding to a point midway through the reproductive cycle. Ovariectomy performed 6-8 days before adult ecdysis results in a drastic decrease in the amount of stored neurosecretory material (NSM) in the brain of 10-day old adults. Administration of B-ecdysone to ovariectomized adults over a 4-day period (days 5-9) results in partial restoration of control levels of PF positive material in the brains of day 10 operated animals. Work to electrophoretically characterize the PF positive NSM stored in the brains of ovulating females is underway. This work was supported by Auburn University Grants-in-Aid 76-135 and 77-150.

OVARY-FAT BODY INTERACTIONS IN THE HOUSE CRICKET

J. T. Bradley, H. C. Chang, and M. L. Nicolaro. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

During the second day of adult life two female-specific proteins appear in the hemolymph of the house cricket, *Acheta domesticus*, and about 18 hours later vitellogenic follicles can be identified in the ovaries. Two proteins electrophoretically indistinguishable (in native polyacrylamide gels) from these account for more than 90% of the soluble yolk protein in mature oocytes. The hemolymph proteins are termed vitellogenins (VG) I and II and the corresponding yolk proteins vitellins I and II. The fat body has been shown to be a site of Vg synthesis. The possible role(s) of the ovary in regulating Vg synthesis by the fat body has been studied utilizing ovariectomized crickets. The induction of Vg synthesis in adult females appears to be independent of the ovaries since neither the time of their appearance nor their initial rate of accumulation in the hemolymph is affected by ovariectomy performed during the last larval instar. However, a post-induction modulation of Vg synthesis via the ovaries is suggested by the fact that the rate of release of newly synthesized Vg from the fat body is greatly reduced in 10-day old ovariectomized females. This phenomenon has been demonstrated both *in vivo* and *in vitro*. Preliminary ultrastructural studies show that fat body cells of ovariectomized animals appear to possess an amount of rough ER comparable to that in control tissue, suggesting that ovariectomy does not significantly alter the synthetic activity of the fat body. This work was supported by Auburn University Grants-in-Aid 76-135 and 77-150.

Abstracts

USE OF CORN MESOPHYLL PROTOPLASTS IN PLANT VIRUS RESEARCH

V. K. Varner and R. T. Gudauskas. Dept. of Botany, Plant Pathology, and Microbiology, Agri. Exp. Station, Auburn Univ., Auburn, AL 36830.

Isolated plant protoplasts hold promise for use in many areas of biological research, including virology. Recent success in infecting tobacco, potato, and cereal protoplasts with some plant viruses prompted studies to develop procedures for isolation of corn protoplasts and infection of them with maize dwarf mosaic virus (MDMV), an important pathogen of corn in Alabama. Protoplasts were harvested from HY X C103 corn seedlings using an isolation medium containing 2% cellulase, 1% macerase, and 0.6 M mannitol. Greatest yields of protoplasts (8.5×10^6 /g fresh tissue) were obtained from 16 day-old seedling. Protoplasts remained viable up to 7 days after isolation in an incubation medium buffered at pH 6.5 and maintained at 30 C under low light intensity. Attempts to infect protoplasts with MDMV are in progress.

SERUM SPECIFIC ELECTRON MICROSCOPY OF SOYBEAN MOSAIC VIRUS

A. Huebner and R. T. Gudauskas. Dept. of Botany, Plant Pathology, and Microbiology, Agri. Exp. Station, Auburn Univ., Auburn, AL 36830.

Samples of suspected virus-diseased soybeans representing 13 cultivars were collected from six locations in Alabama during late fall of 1979. Extracts from each sample were assayed for viruses by inoculation onto healthy test plants in the greenhouse and by serum specific electron microscopy (SSEM). For the latter, extracts were reacted with antisera to alfalfa mosaic, bean pod mottle, bean yellow mosaic, cowpea chlorotic mottle, cowpea mosaic, soybean mosaic, and tobacco ringspot viruses, then stained and examined with a Philips 300 electron microscope. Soybean mosaic virus was identified by SSEM in extracts from 'Bragg' soybeans collected near Tallassee and from 'Hutton' and 'Dowling' soybeans collected near Milstead; no other viruses were detected in any of the samples collected in 1979. In 1980, soybean plantings will be sampled throughout the growing season in an attempt to detect viruses which might become obscure as soybeans near maturity.

METABOLIC EFFECTS OF PRECOCENE TREATMENT IN THE CRICKET (*ACHETA DOMESTICUS*)

Philip A. Crockett, Lawrence C. Wit, and James T. Bradley. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

Immature female crickets (*Acheta domesticus*) were treated with precocene 2 in an attempt to ascertain the sensitivity of the house cricket to the reported anti-juvenile hormone effects of the precocenes. Prior to the adult molt immature crickets were exposed to precocene-treated petri dishes. At 24 and 72 hours post-molt hemolymph was removed and analyzed by SDS polyacrylamide gel electrophoresis for the presence of vitellogenins. Vitellogenins are female-specific yolk proteins produced

by the fat body under the influence of juvenile hormone. Analysis revealed that there were no differences between precocene-treated and control groups with respect to the appearance of vitellogenins. It was concluded that *Acheta domesticus* is insensitive to the effect of precocene 2 in altering this juvenile hormone-dependent phenomenon.

ASPECTS OF THE NATURAL HISTORY OF *CNEMIDOPHORUS*
SEXLINEATUS DURING HIBERNATION

Kay E. Gilligan, Lawrence C. Wit, Jeffrey C. Sellers, and Stanley E. Trauth. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

Cnemidophorus sexlineatus, the six-lined racerunner, spends approximately three-fourths of its life in hibernation. This study investigated behavioral and physiological changes associated with hibernation in this lizard. Lizards were collected biweekly from May 1978 to September 1979 from several sites in east Alabama and west Georgia; additionally, chronic observations were made of a field population during the same period. Adult lizards entered hibernacula from late August to mid-September. Some juvenile lizards began hibernating in September, while others were observed active as late as November. Juveniles were the first to emerge, with active individuals seen in mid-March. Adult males began to emerge by mid-April, and adult females in mid-May. Prior to hibernation, behavioral changes occurred in the type of burrow excavated. Shallow activity burrows were replaced by deep hibernation burrows. Hibernation burrows averaged 13.8 cm in depth, 20.1 cm in length, and 2.3 cm in diameter. Physiological changes which occurred prior to hibernation included storage of fat in coelomic fat bodies and gonadal regression. Female lizards stored significantly more fat than males. Only a portion of this stored fat was metabolized during hibernation in both sexes. A majority of the remaining fat stores appeared to be utilized during reproductive efforts. Prior to emergence, females exhibited follicle enlargement and yolking, and males began spermatogenesis. Potential environmental cues for entrance and emergence are discussed.

OCCURRENCES OF AORTIC ATHEROSCLEROSIS IN THE
ALABAMA WILD TURKEY

S. L. Bolden and G. R. McDaniel, Dept. of Poultry Science, Agri. Exp. Station, and L. M. Krista, Dept. of Anatomy & Histology, School of Veterinary Medicine, Auburn Univ., Auburn, AL 36830.

This study was conducted for the purpose of comparing intimal changes in the aortas of wild turkeys to that of domesticated species. Several experiments have shown that atherosclerotic plaques exist spontaneously in the domestic turkeys. In fact, the turkey is the only known animal with a natural incidence of dissecting aneurysm. There has been little data published on the wild turkey concerning atherosclerosis. Aortas were excised from wild turkeys killed by hunters in Alabama, after which they were prepared using conventional histopathological techniques. An abdominal aortic atherosclerotic score was then recorded for each bird.

Abstracts

Aortic intimal changes were found in the wild turkey. The lesions were similar to those found in domestic turkeys; however, they were less extensive.

BEHAVIORAL STUDIES OF THE TELEOST *FUNDULUS GRANDIS*

Patricia McKee Pagel, Robert MacGregor III, and William Siler. Dept. of Biology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Qualitative observations were made on reproductive and agonistic behaviors of the estaurine Gulf Killifish, *Fundulus grandis*. Adult fish were maintained on a stimulatory photoperiod of LD 15:9 at approximately 22°C. Reproductive behavior patterns include herding, quivering, clasping and spawning. Unreceptive behavior by female includes fleeing, chasing and an "unreceptive stance." Agonistic behavior includes rapid approach, chase, lateral display, operculum spread, tailbeat, head-to-tail bout and occasional mouth lock. Submissive behavior includes fleeing and hiding. All agonistic behaviors have been seen in both sexes in male-male encounters and also in male-female encounters. There may be the potential for limited parental care although it has not been established whether or not this occurs in the fish's natural habitat. Reproductive and agonistic coloration patterns were observed. Coloration and size of fish are both important factors involved with social interaction in *F. grandis*.

ENDOGENOUS STAGES OF *EIMERIA TUSKEGEENSIS* IN THE COTTON RAT

William L. Current, Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830. John V. Ernst, USDA Regional Parasite Lab., Auburn, AL 36830.

Endogenous stages of *Eimeria tuskegeensis* were studied in experimentally infected cotton rats. All parasites were located in epithelial cells on the sides and tips of the villi of the small intestine. First generation schizonts, $14.3 \times 13.2 \mu\text{m}$, were found 36 to 72 h post inoculation (PI). They contained 22 to 30 merozoites and a small residual body. Second generation schizonts, $24.7 \times 28.7 \mu\text{m}$, were found 60 to 96 h PI and contained 48 to 62 merozoites and a large residual body. Third generation schizonts, $11.7 \times 10.3 \mu\text{m}$, were found 84 to 120 h PI and contained 24 to 20 merozoites and no residual body. Macrogametes and microgametocytes were found 96 to 120 h PI. Two types of wall forming bodies were present in macrogametes. Mature macrogametes measured 20 to 28 by 12 to 18 μm . The microgametocyte had a monocentric type of development and measured 25 to 30 by 12 to 20 μm when mature.

Abstracts

EIMERIA TUSKEGEENSIS IN THE COTTON RAT: ACTIVELY INDUCED RESISTANCE

Jayma A. Moore and William L. Current, Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830. John V. Ernst, USDA Regional Parasite Research Lab., Auburn, AL 36830.

Compelled work indicates that cotton rats (*Sigmodon hispidus*) are completely resistant to reinfection with *Eimeria tuskegensis* (Protozoa: Eimeriidae) after a single inoculation of 2000 or more oocysts of the same species. Resistance lasts at least four weeks. To determine what stages of the parasite were affected, experimental rats previously inoculated with 10,000 oocysts and control rats free of the parasite were challenged orally with 50,000 to 900,000 oocysts. Rats from each group were necropsied at 24-hour intervals and examined for parasite development. In control rats, sporozoites penetrated into intestinal epithelial cells and proceeded through the normal endogenous development of three generations of schizogony followed by gametogony. In experimental rats, sporozoites were apparently killed before penetrating the epithelial cells. The mechanisms responsible for inactivation of the infective sporozoite stage are now being investigated.

ULTRASTRUCTURE OF *MYXOBILATUS* SP. (MYXOSPORIDA) IN THE LARGEMOUTH BASS

O. J. Booker and W. L. Current, Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

Scanning electron microscopy revealed that vegetative stages (plasmodia) were firmly attached to the surface of the urinary bladder. Transmission electron microscopy of the species-to-species interface revealed that plasmodia possess numerous pseudopodia which were inserted into channels formed by infoldings of the host cell membrane. Formation of the channels appeared to be parasite induced. Topography of the unattached surface of the plasmodium is that of fine, branched microvilli which project into the lumen of the urinary bladder. Smaller plasmodia, floating freely within the urinary bladder, are apparently derived from the larger, attached plasmodia by a budding process. Due to the extreme osmiophilic nature of the parasite, resolution of internal structures of plasmodia by standard EM techniques is very difficult. Studies are now underway to resolve this problem and to reconstruct some of the cellular events of sporogenesis.

THE REPRODUCTIVE SYSTEM OF ONE SPECIES OF THE FAMILY CARCHARINIDAE

Edward Rosa and Carol Williams, Dept. of Biology, Carver Research Laboratories, Tuskegee Institute, Tuskegee Institute, AL 36088.

One of the reasons sharks, skates, and rays have been among the most successful vertebrates is due to the possession of a combination of very

Abstracts

generalized and highly specialized organ systems. Of the specialized systems none is more varied, nor in many instances, more highly specialized than the reproductive system. To better understand some aspects of the population dynamics and behavior of elasmobranchs, attention should be directed to this important system. Emphasis will be placed on similarities and differences in certain aspects of reproductive systems of the Family Carcharinidae. Special attention will be placed on the species *Carcharhinus limbatus* (Valenciennes), the Black tip shark.

DEVELOPMENT OF SNAIL EMBRYOS TREATED WITH ORGANIC MERCURY

Hyacinth K. Prince and Ellen W. McLaughlin. Dept. of Biology, Samford Univ., Birmingham, AL 35209.

Eggs in the early cleavage stage of the common pond snail, *Helisoma* sp. were continuously treated with five organic mercury compounds to establish lethal concentrations and to determine if any abnormalities were caused by them. The five compounds, mercuric acetate (MA), phenyl mercuric acetate (PMA), p-amino phenyl mercuric acetate (APMA), chloro-mercurobenzoic acid (CMBA) and diphenyl mercury (DM) were tested at concentrations of 1000 ppm, 100 ppm, 10 ppm, 1.0 ppm, 0.1 ppm, 0.01 ppm, 0.001 ppm and 0.0001 ppm for twenty days. A daily record of mortality, hatching and visible deformities was kept for the experimental and control groups. All survivors were observed for twenty days or until hatching was completed. Lethal concentrations (doses that produced 100% mortality within 24 to 48 hours) were established for the five compounds. The lethal dose was 10 ppm for CMBA, 1.0 ppm for MA, PMA and APMA and 0.01 ppm for DM. In addition, PMA had a low survival rate (14%) at 0.1 ppm and none of these snails hatched. Growth was retarded and hatching delayed in 0.1 ppm APMA. Snails developed and hatched normally in all other concentrations of PMA, APMA and MA. Snails surviving in concentrations of 1.0 ppm CMBA and below showed a marked delay in hatching time. No consistent developmental abnormalities could be attributed to any of the compounds. With all factors considered, DM can be ranked as the most toxic followed by PMA, APMA, MA and CMBA in order of decreasing toxicity.

CORTICOSTERONE BINDING ACTIVITY IN ADRENAL INCUBATION MEDIA

M. L. Till, J. F. Pritchett, J. T. Bradley, D. N. Marple, and L. C. Wit. Auburn Univ. Agri. Exp. Station, Auburn, AL 36830.

Competitive protein binding (CPB) radioassay procedures for plasma corticoids involve an initial extraction to eliminate plasma binding proteins which might compete with the assay protein for the steroid being quantitated. Since these proteins were expected to be minimal in adrenal incubation media, an attempt was made to eliminate the extraction step. However subsequent values suggested variable corticoid binding activity of the incubation media which appeared to be dependent upon glandular activity. Therefore the influence of *in vivo* or *in vitro* administration of ACTH upon *in vitro* corticosterone production as well as

^3H corticosterone binding activity of incubation media have been examined. ACTH, both *in vivo* and *in vitro*, elevated corticosterone secretion and ^3H corticosterone binding activity during initial incubations. Ensuing incubations were characterized by a decline in binding activity. Corticosteroidogenic responses to ACTH remained intact during ensuing incubations. The data suggest the presence of an ACTH-sensitive intraglandular corticoid binding ligand, the activity of which is related to incubation protocol and functional status of the gland.

NOISE STRESS AND CORTICOID BINDING IN ADRENAL INCUBATION MEDIA

W. L. Harper, J. F. Pritchett, M. L. Till, J. T. Bradley, D. N. Marple, and L. C. Wit. Auburn Univ. Agri. Exp. Station, Auburn, AL 36830.

Previous reports from this laboratory have suggested A) altered responsiveness to *in vivo* or *in vitro* ACTH in noise-exposed as compared to control animals and B) altered corticoid binding activity of adrenal incubation media in non-stressed animals. The present study was undertaken to monitor corticoid binding activity in response to *in vivo* and *in vitro* ACTH administration in noise-exposed animals. Male rats (Sprague-Dawley) were subjected to high intensity white noise (110 dBA sound pressure level) for 60 seconds followed by 300 seconds of silence, continuously for 10 consecutive weeks. Adrenal quarters from these and control animals were initially incubated in the presence of graded ACTH levels. Incubation media exhibited a progressive increase in corticoid binding activity in the control but not noise-exposed group. After initial 60 minute basal incubations, subsequent incubation with graded ACTH levels resulted in no noise-ACTH interaction with regard to binding activity. *In vivo* ACTH administration 1 hour prior to sacrifice elevated corticoid binding activity during initial incubation in both control and noise-exposed groups. However the magnitude of the increase was significantly lower in the noise exposed group. The data suggest the presence of an intraglandular corticoid binding ligand which may be implicated in altered adrenal response to ACTH in noise-exposed animals.

PROTEINASE INHIBITORS IN THE MALE REPRODUCTIVE TRACT OF MICE

Lois Hudson and Gary R. Poirier. Dept. of Biology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The levels of proteinase inhibitors in the epididymides and seminal vesicles of maturing mice were compared to the levels of known androgen-dependent products of these tissues. Further modifications in the levels of these products were induced by injections of the antiandrogen, cyproterone acetate. Inhibitor levels in the seminal vesicle paralleled the increase in fructose content at puberty. Cyproterone acetate treatment significantly decreases the level of fructose and inhibitor as well as the size of the seminal vesicles. Although cyproterone acetate reduced the size of the epididymis and the level of sialic acid it had no effect on the inhibitor level even though a pubertal rise in the level

Abstracts

was observed. These data are interpreted to mean that the production of the seminal vesicle inhibitor is androgen dependent while the inhibitor associated with the epididymis is made in the testes and transported to the epididymis.

REPRODUCTION IN FISH: IS 5-DIHYDROTESTOSTERONE INVOLVED?

Mark S. Greeley and Robert MacGregor III, Dept. of Biology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

In mammals, 5-dihydrotestosterone (DHT) has been shown to be a very potent metabolite of testosterone (T). Little is known concerning the importance of this androgen in lower vertebrates, and especially in fish where DHT has not been identified. We report here the first evidence for the presence of DHT in fish. Though sephadex LH-20 separation and radioimmunoassay quantitation, DHT activity was found in the plasma and gonads of the gulf killifish, *Fundulus grandis*, and in serum of king mackerel, *Scomberomus cavalla*, and the bluefish, *Pomatomus saltatrix*. In sexually mature male and female *F. grandis*, both DHT and T peaked at 1.5ng/ml, although not concurrently, while a mixture of 11-hydroxytestosterone (HT) and 11-ketotestosterone (a unique and potent androgen of fish) reached 7.0ng/ml. In a pool of sexually developing fish were found 0.4ng/ml of DHT and 2.5ng/ml of T (males) and nondetectable DHT and 0.4ng/ml of T (females) in plasma. Testes of this pool contained 1.4ng/g of DHT, 2.8ng/g of T and 7.0ng/g of K-HT. Ovaries contained 1.1ng/g of DHT, 0.4ng/g of T and 1.5ng/g of K-HT. In sexually mature bluefish, 0.4ng/ml of DHT and 0.9ng/ml of T (males) and 1.7ng/ml of DHT and 2.5ng/ml of T (females) were found. In both developing and recently spent king mackerel, over 15ng/ml of DHT (males) and 1-10 ng/ml of DHT (females) was present. The possible significance of DHT in fish deserves further study as a result of this observed widespread hormone activity. (Supported by UAB Faculty Research Grant to R.M.)

LOCATION OF Na^+K^+ -ACTIVATED ADENOSINE TRIPHOSPHATASE, CYTOCHROME OXIDASE AND GLUCOSE-6-PHOSPHATASE FROM GRADIENT PURIFIED GILL TISSUE OF THE BLUE CRAB (*CALLINECTES SAPIDUS*)

Steve Dawson and George B. Cline, Dept. of Biology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The gill membranes of the blue crab are involved in ion regulations and the Na^+K^+ ATPase has been implicated as the regulation site. To verify that the ATPase is localized in the plasma membranes and not in other endomembranes, a density gradient fractionation procedure was devised to prepare purified gill cell components for analysis. Crab gills were dissected and sonicated to remove the tissue from underlying supporting structures. Chitinase and collagenase were used in initial studies to increase the cell yield. Cell fragments were separated into four or more zones on the basis of isopycnic banding in a 600 ml sucrose density gradient in a B-XIV zonal rotor. Results show that two membrane fractions are purified. The lower density fraction at 1.13 g/cc should

Abstracts

be plasma membrane vesicles while the higher density fraction at 1.17 should be plasma membrane sheets held together by junctional complexes. Purified mitochondria (as localized by cytochrome oxidase) and purified endoplasmic reticulum (as localized by glucose-6-phosphatase) are recovered as separate zones from the same gradient. The relationship between animal adaptation at different salinities and levels of enzyme activity in different purified subcellular components of gill cells is being studied.

ESTROGEN REVERSAL OF VIABLASTINE INDUCED MICROTUBULAR PARACRYSTALS

H. J. Wilson, R. R. Bridges, and P. S. Campbell. Dept. of Biology, Univ. of Ala. in Huntsville, Huntsville, AL 35807.

Negative effects of viablastine sulfate on the nuclear translocation of estradiol and subsequent uterine responsivity have been variously described as retardation, impendance, etc., in this laboratory and by others. In order to try and determine if specific structural correlates to reduced or retarded responsivity exist, uteri from 21-day old ovariectomized rats, were incubated in Eagle's medium containing 1.8×10^{-4} vinblastine sulfate (VBS) followed by incubation in Eagle's medium containing 10^{-8} M estradiol- 17β . Tissues were subsequently prepared for electron microscopy following each incubation period. Control tissues were incubated in Eagle's medium alone. Cytoplasmic microtubular paracrystals found following incubation in VBS were absent in tissues which were subsequently incubated in estradiol. This apparent estrogen reversal of vinblastine induced microtubular paracrystals provides a plausible explanation to the reported retardation of uterine responsivity by VBS rather than inhibition.

TEMPERATURE ACCLIMATION IN A HIBERNATOR, AN ADAPTIVE STRATEGY?

Isabel M. Ragland, Lawrence C. Wit, and John F. Pritchett. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

An investigation was undertaken to comparatively evaluate temperature acclimation in *Cnemidophorus sexlineatus*, a lizard hibernating during the winter, and *Anolis carolinensis*, which is periodically active during the winter. Although temperature acclimation would be of adaptive value in an animal maintaining activity at colder temperature, it would seem to be nonadaptive in a hibernating poikilotherm primarily because of the energy costs involved. This study was divided into two phases. Phase I involved lab acclimation of *C. sexlineatus* and *A. carolinensis* to either 10° or 30°C for 14 days. Metabolic rates were determined by measuring oxygen consumption at 10°, 20°, and 30°C using a Scholander type respirometer. In the second phase, *C. sexlineatus* and *A. carolinensis* were collected from east, central Alabama and west, central Georgia during the winter and metabolic rates were determined at 10°, 20°, and 30°C. The results indicate that *C. sexlineatus* is unable to cold acclimate and

Abstracts

therefore does not waste energy stores. *A. carolinensis*, however, is able to cold acclimate, and therefore capable of being active at colder temperatures.

CIRCANNUAL PLASMA T₄ TITERS IN THE LIZARD *CNEMIDOPHORUS SEXLINEATUS*

Jeffrey C. Sellers, Lawrence C. Wit, V. K. Ganjam, Kay E. Gilligan, and John F. Pritchett. Depts. of Zoology-Entomology and Veterinary Physiology, Auburn Univ., Auburn, AL 36830.

Approximately 10 *Cnemidophorus sexlineatus* were collected in the field biweekly from May, 1978 to September, 1979. Free flowing blood was collected from an incision made at the base of the tail. Plasma T₄ titers of these blood samples were determined using a radioimmunoassay. Mean plasma titers ranged from .11 to .42 $\mu\text{g}\%$ T₄. No significant differences were found between plasma T₄ titers of males and females. Mean plasma T₄ concentration ($\mu\text{g}\%$) was plotted against the collection date. Analysis of these data indicates the presence of a significant curvilinear response with lower titers during the summer months and higher titers during other months, thus suggesting definite seasonal changes in plasma T₄ titers. These seasonal fluctuations could not be explained in terms of changing soil temperature, rather, these abrupt seasonal changes in plasma T₄ titers coincided best with entry into and emergence from hibernation. A Duncan's multiple range test was performed between the mean T₄ titers of active and hibernating lizards. Plasma T₄ titers of hibernating lizards were significantly higher ($P < .05$) than those of active lizards.

AN ULTRASTRUCTURAL STUDY OF *VALVISPORITES AURITUS* (ZERNDT) BHARDWAJ, A MIDDLE PENNSYLVANIAN LYCOPSID MEGASPORE FROM SOUTHERN ILLINOIS

Robert A. Gastaldo, Dept. of Geology, Auburn Univ., Auburn, AL 36830.

The Lycopodophytina are the dominant component of the Early and Middle Pennsylvanian coal swamps of the northern hemisphere. Two heterosporous reproductive strategies evolved within the Lepidodendraceae. One strategy involves the proliferate development of megaspores within the megasporangium which are released to the environment. *Valvisporites auritus* (Zerndt) Bhardwaj is a megaspore representative of this mode of reproductive strategy. More than 520 megaspores are produced within the megasporangium, and upon maturation, are liberated by a rupture of the megasporangial wall. An authigenically cemented megasporangium with *in situ* megaspores from the Middle Pennsylvanian of southern Illinois has been collected, and the megaspores examined by means of light, scanning and transmission electron microscopy. The megaspore diameter ranges from 77 μm to 1148 μm and is triangular to trilobate in outline with the development of bulbous projections at the radial extremities. Although the proximal and distal surfaces are reported to be smooth when viewed by conventional light microscopy, scanning electron microscopy reveals

Abstracts

an anastomosing network of sporopollenin rods covering both surfaces. Where the distal and proximal surfaces converge, a smooth cingulum is formed. Transmission electron micrographs reveal a stratified ectexine and a homogenous endexine similar to the structure reported for other extinct and extant heterosporous lycopods. It appears that the structural characters of the megaspore wall became established during the Carboniferous Period and have been retained by extant members of the Lycopodiophytina.

THE MALE REPRODUCTIVE CYCLE OF *STERNOTHERUS MINOR DEPRESSUS*

David K. Close and Ken R. Marion. Dept. of Biology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Seasonal testicular changes were studied in the flattened musk turtle, *Sternotherus minor depressus*, during 1979 in north-central Alabama. Testes were histologically prepared and examined for seasonal changes in the germinal epithelium and for the presence of epididymal sperm. Mature spermatozoa were found in epididymides throughout the year, but the organ was noticeably larger during spring. The spermatogenic cycle was initiated in mid-spring with the appearance of primary spermatocytes in the germinal epithelium of the seminiferous tubules. Mature spermatozoa were found in the testes by mid-summer. By October, spermatogenic activity had essentially ceased, though some spermatozoa were still present. Weights of testes followed a similar pattern, being minimum in spring and peaking during fall.

SEASONAL SPERMATOGENESIS OF *STERNOTHERUS ODORATUS* IN NORTH ALABAMA

Roger J. McPherson and Ken R. Marion. Dept. of Biology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Seasonal changes in spermatogenesis were studied in the stinkpot turtle, *Sternotherus odoratus*, during 1979 in Jefferson County, Alabama. Sixty-nine males were collected and histologically examined for spermatogenic stages and presence of epididymal sperm. All animals examined had mature spermatozoa in their epididymides. Testicular spermatogenic activity began during April-May, with the appearance of increased numbers of spermatogonia. Mature spermatozoa appeared during June and became abundant by July. Maximum spermatogenic activity was reached during August through mid-October. During fall, there was a decline in spermatogenic activity, which continued throughout the winter. Our observations of fall copulation and histological examination of the epididymides suggest that this species is capable of mating during any season, with the probable exception of the dormant overwintering period.

Abstracts

ULTRASTRUCTURAL STUDIES OF *YERSINIA ENTEROCOLITICA*

Fahimeh Rahimian, Zoe A. Evans, and Junius M. Clark. Dept. of Biology, Univ. of Ala. in Huntsville, Huntsville, AL 35807.

Ultrastructural studies were made of two human isolates of *Yersinia enterocolitica*. Each strain was grown in an enriched broth as well as in a minimal broth. Cultures were incubated both aerobically and anaerobically at 37°C and 22°C. Following incubation for specified time intervals whole cells and thin sections were examined by transmission electron microscopy. Cells of both strains produced flagella averaging 18 nm in diameter within 24 hr when grown in the enriched medium and incubated either aerobically or anaerobically at 22°C. In addition, small appendages 12 nm in diameter were evident on cells of both strains grown at 37°C in the enriched medium. When grown in minimal medium under aerobic conditions only one strain produced flagella at 22°C whereas similar cultures grown under anaerobic conditions showed slow growth of the bacteria and few flagella were produced. All cultures in minimal medium incubated at 37°C produced poor growth of the organisms regardless of culture atmosphere and flagella could not be detected. These findings indicate that flagellation of *Yersinia enterocolitica* is dependent on growth conditions of the organisms.

RHIZOSPHERE EFFECT OF HERBICIDE-STRESSED SICKLEPOD (*CASSIA OBTUSIFOLIA*) ON *FUSARIUM OXYSPORUM* F. SP. *VASINFECTUM*

Steve L. Brown and E. A. Curl, Dept. of Botany, Plant Pathology, and Microbiology, Auburn Univ., Auburn, AL 36830.

An investigation was conducted *in vitro* to determine the relationship between herbicide stress and root exudation of cotton-field weed plants and the fate of chlamydo-spores of the cotton wilt pathogen, *Fusarium oxysporum* f. sp. *vasinfectum*. Based on preliminary screening with root exudates from eight common weed plants for effects on spore germination of the fungus, sicklepod was selected for further study. Three-day-old sicklepod plants, aseptically grown in water and foliar treated with the herbicide linuron [3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea], released root exudate containing 19.8% more dry weight of material than that released from healthy plants. Germination of *Fusarium* chlamydo-spores in nonsterilized soil from the rhizosphere of herbicide-stressed plants was significantly less than the fungistatic value in soil from a healthy-plant rhizosphere. Chlamydo-spore production in the rhizosphere was reduced by herbicide treatment of sicklepod grown in sterilized soil, but there was no effect when plants were grown in soil with a natural microflora. These results suggest that herbicide-induced alteration of root exudation by a non-crop plant may affect the availability of pathogen inoculum.

Abstracts

CRYSTALLOGRAPHIC STUDIES OF PISUM SATVUM AGGLUTININ

James McDuffy, Edward J. Meehan, Jr. Dept. of Physics and Chemistry, Univ. of Ala. in Huntsville, Huntsville, AL 35807. F. L. Suddath and Charles E. Bugg. Dept. of Biochemistry, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The mitogenic lectin from the green pea, *Pisum sativum* Agglutinin (PSA), has been isolated using affinity chromatography, and its physical and biological properties characterized. Very large single crystals of PSA have been grown from polyethylene glycol solutions. The crystals are orthorhombic, space group $P_{2_1}2_12_1$, diffract to 1.8Å resolution, and are stable in the x-ray beam. The unit cell parameters are $a = 50.85(5)$, $b = 61.23(5)$, and $c = 137.3(2)$ Å. The density of the PSA crystals, as measured by the ficoll gradient technique is 1.196 g cm^{-3} . The calculated mass of protein per asymmetric unit is 49,000 daltons and the crystals are 44% solvent by volume. There is, therefore, one complete PSA molecule, a dimer, per asymmetric unit. The crystalline volume/mass ratio is $2.20 \text{ Å}^3/\text{dalton}$. Six angstrom data from native crystals and from a heavy atom derivative have been collected with a Picker FACS-1 x-ray diffractometer, by use of a scintillation counter and nickel-filtered Cu radiation. The heavy atom was prepared by soaking the native crystals in mother liquor containing 1 mM uranyl nitrate for 24 hr. The coordinates of the uranium atom were obtained from a three dimensional Patterson map and refined by least-squares techniques to an R index of .45. A three dimensional Fourier synthesis was calculated with phases obtained from the single isomorphous derivative together with its anomalous component. The molecular boundary of the PSA dimer is clearly visible in the map.

WRIGHT AUSTIN GARDNER

Emmett B. Carmichael, Professor Emeritus of Biochemistry. Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Wright Austin Gardner was born on a farm in Livingston County, Michigan, 6/6/78. He received the B.S. degree, Albion College, Albion, Michigan, 1902 and the M.A. degree, University of Michigan, 1915. He earned the Ph.D. degree Cum Laude, University of Chicago, 1916. He was Professor of Botany and Plant Pathology, A.P.I., 1917-1931. He founded the Alabama Academy of Science, 1924 and was co-founder of the American Society of Plant Physiologists in 1925. His dissertation for the Ph.D. degree was on the effect of light on the germination of seeds and his researches antedated the studies by Borthwick and associates, Dept. of Agriculture, who isolated the active chemical, phytochrome. Gardner's forte in teaching was his ability or insight to guide better than average students to graduate studies at other institutions. His four children: Harmon Austin; Louis Wright; Mabel Grace; and Donald Anderson graduated with B.S. degrees at A.P.I. and three of them did post-graduate study at other institutions. Dr. Gardner retired in 1931 and operated a jersey dairy at Auburn for 35 years. Dr. Gardner died on May 31, 1966 and his body was interred in Pine Hill Cemetery, Auburn.

Abstracts

AVERAGE INBREEDING COEFFICIENTS IN REGISTERED DACHSHUNDS

Mary U. Ball. Dept. of Zoology-Entomology, Auburn Univ., Auburn, AL 36830.

The availability of computer programs which calculate inbreeding coefficients has resulted in their being used to interpret phenotypic variation in pedigreed populations of mammals both in terms of gene action and the effect of inbreeding on economic traits. A commonly reported population attribute is α , the "average inbreeding coefficient." In estimating α , some authors average only the inbreeding coefficients based on 6-generation pedigrees, while some computer programs calculate and average the inbreeding coefficients for all entries, regardless of the completeness of the pedigree data. Since inadequate information may account for any zero value, and even non-zero values are minimum estimates at best, the arithmetic means tends to underestimate the true population α . Thus, other measures of the inbreeding levels in a population, such as range and mean for non-zero values, % inbred individuals, and % consanguineous matings, should be considered in describing the degree of inbreeding in a population. As part of our study of disc disease in registered dachshunds, inbreeding coefficients are being calculated using the 1972 SAS statistical package, which averages all values to estimate α . Of the animals evaluated so far, 34% are inbred, with the level of inbreeding ranging from .002 to .400. Thus, although estimates of α are low (about .04) a substantial level of inbreeding has been achieved in some individuals.

DENSITY AND AGE STRUCTURE OF THE SURF CLAM

DONAX DOROTHEAE

Gerald T. Regan. Dept. of Biology, Spring Hill College, Mobile, AL 36608.

This species had been recognized as distinct from the coquina clam of the northeastern Gulf Coast, *D. variabilis*, itself renamed *roemeri* (J. P. E. Morrison. 1971. Proc. Biol. Soc. Wash. 83:545.). At Dauphin Island, Alabama, I studied equal-effort bottom samples from the Gulf side during 1978-79. Samples collected only a few meters from the beach of the eastern half of the island had no specimens from January through May. Mean density peaked at 116/square M in August and dropped gradually through the rest of the year. Samples collected along transects perpendicular to the beach peaked at 400/square M a distance 30 M out and dropped quickly to a low level about 50 M out. Five out of eight samples collected from June through September showed clumping as measured by a variance-to-mean ratio tested at the 95 per cent level. Immigration and emigration seem to be the main factors in variation of density. The clam moves by increasing its buoyancy and riding the tidal and other currents. Predation is another factor. Pompanos, crabs, and drilling gastropods are predators. I approached the role of reproduction by analysis of age-size structure. At the east end of the island, the modal class was always the 2-4 mm class, and the frequency of larger classes dropped to zero at 8 mm. At the center of the island, however, there was a

Abstracts

second mode at 10-11 mm, disjunct from the classes below 8 mm. The longest specimen observed was 12 mm. If the second mode represents clams more than one year old, the major part of the density is caused by young of the year. Well developed gonads in some of the latter make it likely that spawning occurs in the first year. The Dauphin Island Sea Lab and Spring Hill College contributed support for this work.

GROWTH AND MORTALITY OF *DONAX DOROTHEAE* AND *DONAX ROEMERI*

Kevin M. Morrissey and Gerald T. Regan. Dept. of Biology, Spring Hill College, Mobile, AL 36608.

On the Alabama shore of the Gulf of Mexico I studied valve size and drill holes during 1979. Samples were collected from death assemblages. Right valves, being the most numerous, were chosen for the study; 397 *dorotheae* and 109 *roemeri* valves were collected. Lengths ranged from 2.3-10.1 mm for *dorotheae*, and 2.9-25.3 for *roemeri*. Weights ranged from 1.0-49.0 mg for *dorotheae*, and 1.4-662.0 mg for *roemeri*. Differences between the length and weight ranges of the two species were significant at the 95 per cent level. *D. dorotheae* exhibits a convex type survivorship curve, while *roemeri* exhibits a modified staircase type. Three types of drill holes were present. Overall, *dorotheae* had the highest percentage of complete drill holes, and the lowest percentage of incomplete drill holes. Length-weight regression curves were expressed as $Y = -0.11747X^3 + 2.79215X^2 - 12.71118X + 18.91056$ for *dorotheae* and $Y = 0.02009X^3 + 0.76978X^2 - 6.6035X + 21.27968$ for *roemeri*, where Y is weight and X is length. Growth for both species was determined to be allometric by use of Bartlett's Line.

ADRIAMYCIN: ITS EFFECT ON DOUBLE MINUTE CHROMOSOMES IN THE BREAST TUMOR CELL LINE SW-613

Leslie C. Parkman. Dept. of Biology, Samford Univ., Birmingham, AL 35209.

The effect of adriamycin on double minute chromosomes (dm) was investigated in the breast adenocarcinoma cell line SW-613. Data collected from a 2 hour pulse and 24 hour continuous treatment with adriamycin showed significant increase of the 24 hour group over the 2 hour group in the number of dm/metaphase cell (52%). Distribution of dm/50 metaphase cells was also significant. Most notable was the 91% increase of the 24 hour group over the 2 hour group in the number of cells which contained 41+ dm/cell.

Abstracts

THE EFFECT OF FLASK DENSITY ON DOUBLE MINUTE CHROMOSOMES IN THE BREAST TUMOR CELL LINE SW-613

Leslie C. Parkman. Dept. of Biology, Samford Univ., Birmingham, AL 35209.

The effect of density on double minute chromosomes (dm) was investigated in the breast adenocarcinoma cell line SW-613. Data collected from the density study, performed in triplicate, revealed significant correlations between dm and density. While little difference existed in the number of dm in the B (1/2 confluent) and C (3/4 confluent) groups, a large difference of 51% existed between the A (1/4 confluent) and D (4/4 confluent) groups. The A group mean showed a 35% decrease in the number of cells with 0-10 dm/cell as compared to the D group, and an increase of 107% in the number of cells with 41+ dm/cell, as compared to the D group.

CHEMISTRY

THE PRODUCTION OF A LABORATORY SAFETY FILM

Fred Allen Gant. Dept. of Chemistry, Jacksonville State Univ., Jacksonville, AL 36265.

Since safety in the laboratory has become more important in the past few years, a safety film was written and produced to inform students of safety procedures and equipment which are used in our laboratories. This film shows the correct use of safety equipment such as fire extinguishers, showers, eye wash fountains, etc. and gives directions to be followed in case of emergency as well as general laboratory behavior. The film was produced with student actors in the chemistry laboratories at J.S.U. with the aide of the university television studio. The film is shown to all chemistry laboratory classes at the first class meeting each semester.

X-RAY CRYSTAL STRUCTURES OF COMPOUNDS RELATED TO $(\eta^5\text{-C}_5\text{H}_4)\text{Cr}(\text{CO})_2(\text{NO})\text{C}(\text{OH})\text{CH}_3(\eta^5\text{-C}_5\text{H}_4)\text{Fe}(\eta^5\text{-C}_5\text{H}_5)$

Michael T. Ledet, Riz Shakir, and Jerry L. Atwood. Dept. of Chemistry, Univ. of Ala., University, AL 35486.

In the past few years we have been interested in elucidating the effect of changing the electronic and steric environment of the metal on the $-\text{Cr}(\text{CO})_2(\text{NO})$ tripod. It has been observed that electronic effects dominate in $(\eta^5\text{-C}_{13}\text{H}_9)\text{Cr}(\text{CO})_2(\text{NO})$ in determining the position of the nitrosyl ligand while the steric factors are more important in $(\eta^5\text{-C}_9\text{H}_7)\text{Cr}(\text{CO})_2(\text{NO})$. We have determined the single crystal X-ray structures of a series of new complexes containing the $-\text{Cr}(\text{CO})_2(\text{NO})$ moiety. The effect of changing the substituent on the cyclopentadienyl ring will be discussed in light of the X-ray results.

Abstracts

NEW LIQUID CLATHRATE SYSTEMS INVOLVING TlSCN AND ALUMINUM ALKYLs

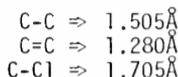
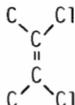
C. Reid Kerr, Riz Shakir, and Jerry L. Atwood. Dept. of Chemistry, Univ. of Ala., University, AL 35486.

In order to gain sufficient insight into the phenomenon of liquid clathrates, it is instructive to examine the Latin root of clathrate. The word clathratus means "enclosed or protected by the cross bars of a grating." Accordingly, the chemical significance of thallium thiocyanate liquid clathrates will depend largely upon the cagelike structure of the molecule. Further, one can describe the liquid clathrate system as consisting of an anionic host structure that will become oriented in a fashion so as to include or trap cation and aromatic molecules. An important concept is that the host and guest may be closely associated and yet not bonded in a chemical sense. Moreover, a major use of liquid clathrates is in the selective separation of aromatic molecules whose structures may differ in only a slight way. Experimentally, thallium thiocyanate liquid clathrates were found in a nitrogen atmosphere dry box by stirring 5 mmole of thallium thiocyanate with excess aromatic solvent. Subsequent addition of 10 mmole of trimethylaluminum resulted in the formation of the liquid clathrate, and upon cooling the liquid clathrate guest molecules are expelled. Thus separation of components of aromatic mixtures may be possible. We examined thallium thiocyanate liquid clathrate complexes in five solvents: reactions proceeded at 100°C for toluene; at 25°C for benzene and p-xylene; an excess of trimethylaluminum produced a liquid clathrate for m-xylene; and there was no reaction in o-xylene. From the above data, it was concluded that further studies on xylene separations would be desirable. In summary, one may find liquid clathrate phenomenon to be interesting, aesthetically pleasing in design and of possible commercial design as well. The future of thallium thiocyanate liquid clathrates and other can only be labeled as very bright.

THE APPLICATION OF X-RAY CRYSTALLOGRAPHY TO PROBLEMS RELATED TO THE PESTICIDE ALDRIN AND RELATED COMPOUNDS

Larry C. Canada, Robin D. Rogers, and Jerry Atwood. Dept. of Chemistry, Univ. of Ala., University, AL 35486.

Aldrin is a white crystalline solid with a molecular weight of 365. First synthesized in 1947, it has been used as an insecticide and has proved 20 times more toxic to most insects than DDT. The crystal structure of the title compound will be compared with several derivatives and related compounds. Interesting variations of the C-Cl bond distances will be discussed as well as the formation of a very strong double bond.



A short preview explaining some of the basic concepts of X-ray crystallography will also be presented.

Abstracts

AN ANTIBIOTIC SUBSTANCE IN YOGURT

David C. Baker, W. Bertsch, J. Hanvey, L. D. Hawkins, H. Heath, J. Parker, and P. Swann. Dept. of Chemistry, Univ. of Ala., University, AL 35486.

Fermentation of milk by *Lactobacillus* organisms has long been claimed to produce substances with antibiotic and/or antitumor properties [Hamdan, I. Y., Mikolajcik, E. M. *Cultured Dairy Prod. Jour.*, 10, 18(1975); Shahani, K. M., Vakil, J. R., and Chardan, R. C. U.S. Patent 3,689,640 (1972)]. In the present investigation, fermentation products of *L. acidophilus* (Milwaukee strain, Hansen's Laboratory) are examined against 27 test microorganisms. Copious quantities of lactic acid produced by the *L. acidophilus* cultures show a marked bacteriostatic effect; however, for a number of organisms (i.e. *S. lutea*, *B. subtilis* and *E. coli*, including the yeast *Kloeckera brevis*), a substantial increase in bacterial inhibition has been found, indicating the presence of an additional antibiotic substance(s). Preparative separation *via* liquid chromatography and analysis by gas-liquid chromatography of suitably derivatized samples is currently being used to isolate and identify the biologically active component(s).

THE SYNTHESIS OF 2-AZIDO- AND 3,6-DIAZIDO-10-METHYL-ACRIDINIUM BROMIDES

A. Ocak, L. Yielding, and R. L. Settime.

In the literature, a variety of simple acridine derivatives have been prepared and shown to exhibit bacterial mutagenic properties by presumably intercalating themselves between the base pairs of the RNA helix of the target bacteria. The elaboration of these parent acridine derivatives to include both variously substituted azido groups and a 10-methyl function in the form of a bromide salt was therefore expected to greatly enhance their bactericidal properties. Several of these azido-10-methyl-acridinium bromides have been synthesized in this laboratory from the corresponding aminoacridines or diamino-10-methylacridinium salts. At the present time, we are involved in the continued study of the structure-reactivity relationships related to the presence and positions of one or more azido functions in the basic acridine nucleus and in the synthesis of a number of amino-azido acridines.

THE ADDITION OF HETEROATOMIC DIENOPHILES TO LEVOPIIMARIC ACID

Joyce Friedrich and Robert Settime.

Various heteroatomic Diels-Alder adducts of levopimaric acid have been synthesized in this and other laboratories. Successful cycloadditions include the reactions of sensitized oxygen, formaldehyde, nitrosobenzenes, 4-phenyl-1,2,4-triazoline-3,5-dione, 1,4-phthalazinedione, N-sulfinyl-4-chlorobenzenesulfonamide, methyl cyanodithioformate, and N-benzoyl-N-phenyl-cyanothioformamide. These dienophiles have thus incorporated O-0,

Abstracts

N-O, N-N, N-S, and C-S linkages within the basic resin acid structure. However, surprisingly little is known about the actual chemistry of these adducts due to their sensitivity to heat and acidic conditions. Efforts are now being made to stabilize these adducts by mildly reducing or cleaving the hin-ered double bond that clearly participates in either the retro Diels-Alder reactions or the elimination of the elements of the dienophile upon hydrolysis. Moderate results have been obtained with diborane reductions and permanganate oxidations. If these stabilization processes prove successful, these resin acid derivatives should serve as an inexpensive and readily available source of the precursors of heterocyclic alkaloid-type or nor-steroidal analogs of interest to the drug-producing industry.

THE SYNTHESIS AND CHEMISTRY OF (R)- AND (S)-2-BENZYLOXYPROPANAL

David C. Baker, L. D. Hawkins, Rembert B. Jarrell, and Raoul Pajares III. Dept. of Chemistry, Univ. of Ala., University, AL 35486.

The synthetically useful, chiral aldehydes, (R)- and (S)-2-benzyloxypropanal (1 and 2) were derived respectively from D-mannose and L-rhamnose. The sequence from D-mannose \rightarrow D-mannose diethylthioacetal \rightarrow D-rhamnitol 1,2:3,4-di-O-isopropylidene-D-rhamnitol \rightarrow 5-O-benzyl-D-rhamnitol \rightarrow (R)-2-benzyloxypropanal (1) proceeded in an overall yield of ca. 35%. A similar sequence from L-rhamnose (via L-rhamnitol) gave the (S)-isomer 2. Both isomers were obtained as optically pure, distillable syrups. Grignard additions to both 1 and 2 show ca. 60:40 mixtures of *threo:erythro* products, indicating participation of the ether oxygen.

THE CRYSTAL STRUCTURE OF $(n^5-C_5H_4SiMe_3)_2Zr(Cl)CH_2C_6Me_5$

William E. Hunter, F. Ruth Anderson, and Jerry L. Atwood. Dept. of Chemistry, Univ. of Ala., University, AL 35486.

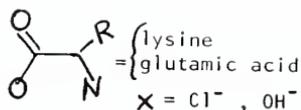
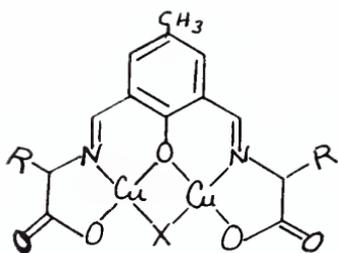
The title compound presents a situation in which the σ -bonded ligand is in a crowded environment. The result is that the σ -bond length, 2.33Å, is significantly elongated over the normal 2.27Å value. The compound will be compared with related substances of formulation Cp_2ZrR_2 and $Cp_2ZrR(Cl)$. The influence of the trimethylsilyl moiety will also be discussed.

SYNTHESIS OF NEW BINUCLEAR COPPER (II) COMPLEXES

Karen Moore and G. S. Vigee. Dept. of Chemistry, Univ. of Ala. in Birmingham, University Station, Birmingham, AL 35294.

Several new binuclear copper (II) complexes have been prepared with Schiff bases derived from the condensation of 2,6-diformyl-4-methylphenol with α amino acids. The general structure of these complexes is:

Abstracts

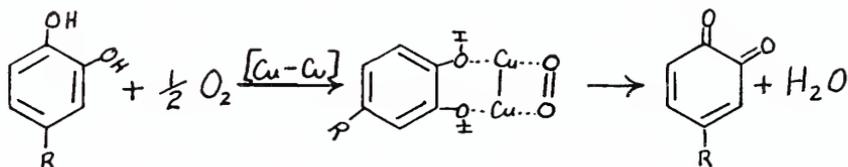


These new complexes have been characterized by elemental analysis and infrared and optical spectroscopy. The magnetic moment of each of the crystalline complexes has been measured by the Gouy method while the magnetic moment of each complex in solution was determined by NMR. The diminished magnetic moments of these complexes is a measure of the spin-pairing between copper (II) ions. The ESR spectra of each complex in solid and in solution were measured and g-values calculated.

BINUCLEAR COPPER COMPLEXES AS CATALYSTS FOR THE AIR OXIDATION OF O-DIPHENOLS

David Bolus and G. S. Vigee. Dept. of Chemistry, Univ. of Ala. in Birmingham, University Station, Birmingham, AL 35294.

Copper in the +1 and +2 oxidation states are found in metalloenzymes in both plant and animal life. One copper enzyme of interest to us is tyrosinase which catalyzes the oxidation reaction of catechols:



Tyrosinase contains a pair of binuclear Cu(II) ions at the active site. The coupled Cu(II) ions are believed to form the tertiary intermediate with dioxygen and catechol in the oxidation process above. Four binuclear complexes have been synthesized to serve as models for tyrosinase. The complexes were characterized by optical (uv-vis-iv) and magnetic studies. Rate studies of the oxidation reaction with varying catechols and pH were also performed. Correlation of the rate studies with optical studies and the effect of pH change are discussed.

THE CRYSTAL AND MOLECULAR STRUCTURE OF BROMOFLUOROACETIC ACID, A CHIRAL HYDROGEN BONDED DIMER

M. Susan Dalton, Robin D. Rogers, Lowell D. Kispert, and Jerry L. Atwood. Dept. of Chemistry, Univ. of Ala., University, AL 35486.

The crystal structure of bromofluoroacetic acid has been determined from three-dimensional counter data, and refined by full-matrix

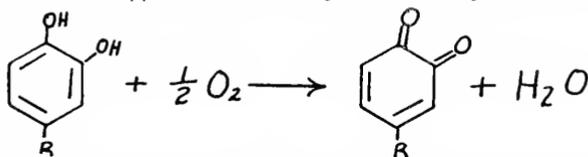
Abstracts

least-squares techniques. The crystals belong to the monoclinic space group P2/c with $a = 8.529(4)$, $b = 5.632(3)$, $c = 9.500(4)$ Å, $\beta = 105.52(4)$ Å, and $D_C = 2.37 \text{ g cm}^{-3}$ for $Z = 4$. The final R factor for 654 independent observed reflections is 0.081. The compound exists as hydrogen-bonded dimers in the solid state.

CATALYTIC COPPER AMINES, AN INVESTIGATION OF THEIR ACTIVE SITES

Etim Eduok and G. S. Vigee. Dept. of Chemistry, Univ. of Ala. in Birmingham, University Station, Birmingham, AL 35294.

Copper ions in copper metalloenzymes are known to be bonded to nitrogen and oxygen ligands. The chemical nature of the ligands and the stereochemistry conferred by them on the copper ion is not well understood because of the inability to isolate the pure enzyme. The aim of this research is to determine the environment of the nitrogen and oxygen ligands which best supports the catalytic activity of the reaction:



To this end, we have prepared several copper complexes in aqueous solution whose ligands are designed to vary the environment and stereochemistry of the copper. Initial rate kinetic studies of 4-methylcatechol with each complex was run by observing the growth of a peak at $\lambda = 438 \text{ nm}$ which is typical of 4-methyl-o-quinone. The rate studies were followed by studies of the copper complex-catechol interaction. Nmr paramagnetic linebroadening (T_2) of the methyl protons was used to measure the effectiveness of Cu^{+2} -catechol bonding in each complex. The subsequent visible study of the change in the d-d spectra of Cu^{+2} in each complex upon addition of catechol shed light on the environmental changes in copper when bonding occurred with the catechol. A correlation of ligand properties and spectral studies is given.

STABLE TRANSITION METAL PENTADIENE COMPLEXES

Ralph D. Priester, Jerry L. Atwood, and Charles U. Pittman, Jr. Dept. of Chemistry, Univ. of Ala., University, AL 35486.

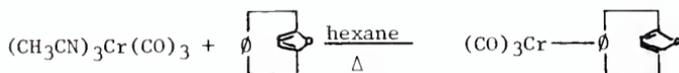
As part of a series of compounds of the form Cp_2MR_2 or Cp_2MHR ($M = \text{Zr, Ti, Hf}$), we now report a new system utilizing the heretofore little noted 1,4-pentadienyl ligand. The pale yellow compounds are isolated from low temperature reactions with Group IVB metallocene dichlorides and characterized by nuclear magnetic resonance spectroscopy. Although several types of coordination are possible, NMR data indicates that the ligand is bonded via a metal-carbon sigma bond.

Abstracts

PREPARATION AND STRUCTURE OF HETEROATOM CYCLOPHANE COMPLEXES OF $-\text{Cr}(\text{CO})_3$

Ricky Stamps, Riz Shakir, and Jerry Atwood. Dept. of Chemistry, Univ. of Ala., University, AL 35486.

[2.2]Cyclophanes have received considerable attention in recent years by researchers studying molecular strain. However, except for [2.2]paracyclophane the literature is devoid of organometallic complexes of these interesting compounds. With this in mind, several [2.2]phanes were synthesized and attempts were made to prepare the corresponding $-\text{Cr}(\text{CO})_3$ complexes. [2.2]2,5 furanoparacyclophane was prepared according to



The compound was characterized by NMR and X-ray diffraction techniques. The yellow, air-stable substance crystallizes in the monoclinic space group P_2/c , and the crystal structure was refined to $R = 0.065$. The synthesis and structure will be discussed.

GEOLOGY

MOISTURE VARIABILITY IN ALABAMA COALS: SOME ECONOMIC PROBLEMS

Reynold Q. Shotts, Dept. of Mineral Engineering, Univ. of Ala., University, AL 35486.

Moisture is present in all coals in place. In fact, it is part of the composition of coals that has not been artificially dried. Moisture has weight but no heating value. The heating value of coal thus is inversely proportional to moisture, a strictly diluent impurity. The unit value of coal should always be determined on the basis, and in the condition, in which it is to be utilized. Sales taxes are usually assessed on the value of a product, but other taxes are assessed per weight unit. In the case of coal, this is the ton or the millions of btu's of heat content. This paper considers the modes of occurrence of moisture in coal and the moisture at various stages and conditions: in the ground, after washing, differences in content due to size, and moisture variabilities encountered. The latter influences the number of tons sold or taxes, as well as the price per unit.

A METAMORPHOSED MAFIC-ULTRAMAFIC PLUTON FROM THE DADEVILLE COMPLEX, TALLAPOOSA COUNTY, ALABAMA

Glenda Fleming, Adrienne Nunan, and Michael J. Neilson. Dept. of Earth Science, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

In the vicinity of Red Ridge Church, some 4.5 km south of Dadeville, a small (less than 1 sq. km) sill-like mafic-ultramafic pluton intrudes

Abstracts

the Ropes Creek Amphibolite. The plutonic rocks and the amphibolites have contrasting textures, mineralogy, and chemistry. Metamorphism has obliterated the original mineralogy of the plutonic rocks, causing either porphyroblastic epidote-hornblende-quartz-chlorite or decussate tremolite-chlorite-quartz-epidote assemblages in the mafic rocks, and chlorite-magnesite-antigorite assemblages in the ultramafic rocks. The Ropes Creek Amphibolite has a gneissic texture and displays assemblages dominated by plagioclase-hornblende-quartz with accessory epidote, sphene, and garnet. Geochemically the plutonic mafic rocks belong to the Doss Mountain type as defined by Neilson (1978), but the compositions and variations shown by the Ropes Creek Amphibolite do not follow either the Doss Mountain or the Slaughters trends as outlined by Neilson and Stow (pers comm).

LOW TEMPERATURE ALTERATION OF FERROBASALTS FROM THE GALAPAGOS SPREADING CENTER, EAST PACIFIC OCEAN

Ed L. Schrader. Dept. of Geology and Geography, Univ. of Ala., University, AL 35486.

Ferrobasalts (Fe-rich, ridge crest tholeiites), from the high heat flow region of the Galapagos Spreading Center, have a distinct secondary mineral assemblage. The secondary minerals fill primary porosity in the basalts, and replace original silicate phases (such as olivine, plagioclase, and glass). The early alteration phases fall into two groups: opaques (pyrite, goethite, minor chalcopyrite, and very minor pyrolusite); and, nonopaques (K-rich and K-poor nontronite, amorphous to crystalline Fe-oxyhydroxides, calcite, and phillipsite). Paragenesis of the most abundant secondary phases in basalt "alteration rinds" is: pyrite (first) → K-poor nontronite → K-rich nontronite → Fe-oxides → ± calcite and/or zeolites (last). Electron microprobe analyses indicate that: the K-poor nontronite is similar in composition to hydrothermally deposited smectites in overlying sediments; alteration of K-poor nontronites involves a net influx of K and Mg, resulting in K-rich nontronite; a relative increase in Fe and decrease in SiO₂ produces Fe-oxides from the nontronites. Eh-pH equilibria diagrams indicate that a change in the systematic oxidation potential occurs between the occurrence of nontronite and the appearance of Fe-oxides. Mineral paragenesis, thus, reflects a change from a hydrothermally dominated alteration process to a seawater dominated process.

STRUCTURAL GEOLOGY OF THE OFOTEN SYNCLINE, NORTHERN NORWAY

Mark G. Steltenpohl. Dept. of Geology and Geography, Univ. of Ala., University, AL 35486.

The Scandinavian Caledonides of N Norway represent a NW-SE trending Paleozoic mountain system with a complex history involving early dynamothermal metamorphism and several phases of deformation. Caledonian rocks of the Ofoten (Of) region lie between Precambrian basement complexes to the NW and SE. Coinciding with the main Caledonian trend is

Abstracts

a large, generally NE trending, shallow plunging synformal fold structure which closes south of the Ofotfjord. Recent investigations in the Of area reveal a miogeoclinal, shelf-like sequence of marbles, quartzites and pelites. An early phase of prograde regional metamorphism, resulting in epidote amphibolite facies assemblages, has produced a pervasive foliation (S1) which parallels the axial planes of early generation flow folds (F2). An obscure, pre-metamorphic folding episode (F1) is suggested by interference patterns, but its importance is not well understood. Several post-metamorphic dynamic events have also been recognized in the Of area. One generation (F4?) is a gentle warping of S1 trending NW-SE, sub-orthogonally to the main synformal axis. The remaining dynamic episodes appear to be coaxial with the Of synform. The first (F3?) is pre-kinematic with respect to the earlier formed cross-folds (F4?). The culminating dynamic event (F5?) is probably cogenetic with the Of synform and folds all previously formed structural elements.

CHARACTERIZATION OF COAL BLUFF BED LIGNITES FROM ALABAMA

Reynold Q. Shotts. Dept. of Mineral Engineering, Univ. of Ala., University, AL 35486.

Analyses of 32 Alabama lignites from the Coal Bluff coalbed, selected from published literature, form the basis for this study. All analyses were calculated to the impurity-free basis (dry, ash-free basis). Sulfur is an impurity but some of it is part of the coal substance (organic) and part of the mineral impurity (sulfide, sulfate) and it was not excluded. Various parts of both the proximate and ultimate analyses, on the impurity-free basis, were plotted as a function of others such as: oxygen content as a function of total carbon; heating value as a function of fixed carbon, of total carbon; of the ratio, VM/FC; of the ratio, atoms of carbon to atoms of hydrogen; and the ratio, atoms of carbon to atoms of oxygen. On the same plots are points representing the same variables and ratios from selected U.S. lignites and, in some cases, from nine selected North Dakota lignites. The Alabama lignites vary considerably and are generally of lower rank and have less heating values than most other lignites.

FORESTRY, GEOGRAPHY, AND CONSERVATION

ALABAMA'S LEGISLATIVE FORESTRY STUDY COMMITTEE

Wilbur B. De Vall, President. Proxy Services Ltd., Auburn, AL 36830.

Alabama's legislature in regular session during 1978 passed Act 515 that created a Forestry Study Committee for one year. Its first report was delivered to the legislature January 15, 1979. The 1979 legislature passed Act No. 79-711 that extended the life of the Committee on an indefinite basis to continue its study of the needs of forestry on a statewide basis. Its first report was delivered to the legislature January 15, 1980. Representative John McMillan, Stockton, Alabama

Abstracts

served as chairman from the beginning. Structured into subcommittees, findings were consolidated into printed reports setting forth recommendations for selected segments of forestry considered on a priority basis. The first report gave priority to wildfire needs. The recommendations numbered 13. The second report updated the first and reported progress and accomplishments during the intervening year. Recommendations were presented according to funds, namely the General Fund and the Special Education Trust Fund. These two funds support, respectively, programs of the Alabama Forestry Commission and Auburn University. Currently the Committee is working with two subcommittees and will hold two meetings at the state capital prior to May 1980 when progress reports will be reviewed by the 15-man Committee. Specific attention is being given to wood as an energy source and forest tree nurseries, the suppliers of tree seedlings for planting on abandoned and cut-over forest lands.

IMPACT OF THE PORT OF MOBILE ON THE ALABAMA ECONOMY

J. R. Hurst, J. L. Stallings, and H. B. Strawn. Auburn Univ., Auburn, AL 36830.

The study utilized three different methods to measure the impact of exports through the Public Grain Elevator at the Port of Mobile on the agricultural and general economy of Alabama. The trends of agricultural production and exports were documented by developing time series using secondary data. The Alabama data indicated a close correlation between production and exports. Trend projection indicated a 78 percent increase to 120 million bushels of grain and products exported by 1984-85. A comparative analysis of U.S. export facilities showed Mobile the most efficient in terms of ratio of loadings to capacity. It was concluded that Mobile had insufficient capacity to handle volume projected for 1984-85. Agricultural commodities are fungible goods that lose identity of origin when comingled, thus a systematic method of allocation developed by USDA was used to allocate shares of exports among counties. The study allocated 1978 exports of major commodities to individual counties and determined a total value of agricultural exports to each county, which totaled \$300 million. "Input-output analysis" was used to estimate the total impact of employment and income on the general economy of Alabama resulting from agricultural exports. The resulting multiplier was applied to the actual volume of agricultural commodities by county in 1977 to determine the impact upon the general economy of each county. The total state impact was \$283 million and 8,562 jobs. The completion of the Tennessee-Tombigbee Waterway should increase the potential volume of exports from Mobile by 1984-85 and its relative impact is indicated in the study by a comparative analysis of rates to Gulf Ports via existing river routes and the new waterway.

Abstracts

CAYMAN BRAC: A FIELD STUDY IN DEMARCATION

David G. Skinner. Dept. of Geology and Geography, Univ. of Ala.

Demarcation and inclusion is a cultural trait well represented on the landscape of Cayman Brac. This phenomenon of demarcation and inclusion and the factors influencing its use is the subject of this study. The use of various methods of establishing boundary designations is reviewed, as well as the history and influences associated with them. Description and explanation of the reasons why boundaries are used and the purpose they serve on Cayman Brac will also be examined and shown to be of a cultural tradition rather than a physical barrier.

PATTERN OF DECLINE IN RETAIL SALES IN CBD'S OF SELECTED ALABAMA CITIES

J. T. Shadinger, Jr. Dept. of Geology and Geography, Univ. of Ala.

The role of the central business district (CBD) as the focal point of retailing in metropolitan areas has been declining in the United States since World War II. This study examines the trends in retail sales and numbers of retail establishments in the CBD's of three Alabama cities between 1948 and 1972. The data indicate a steady decline in the retail function since the early 1950's. Also, various periods are identified that would tend to indicate an association between the declining retail function and the overall changing character of the CBD itself.

URBAN SPECULATION IN THE TOMBIGBEE VALLEY BEFORE THE CIVIL WAR

David C. Weaver. Dept. of Geology and Geography, Univ. of Ala., Tuscaloosa, AL.

Both the Upland South and Lowland South cultural traditions have been viewed as fundamentally anti-urban in character. While this characterization may be justified, overemphasis on the role of these traditions in conditioning the settlement pattern of the South may be misleading. Research indicates that in the early years of colonization on the southern frontier a significant town building tradition operated concurrently with the rurally oriented agricultural settlement systems. The pattern of such urban development is illustrated as it occurred in an area of the South, the Upper Tombigbee Valley in the mid-nineteenth century.

Abstracts

TEMPERATURE TRENDS IN FLORENCE, ALABAMA, 1920-1977

Frank N. Himmler and Sherrie Soustek Mathews. Dept. of Geography, Univ. of N. Ala., Florence, AL.

A recent series of colder than normal winters in north Alabama has provoked considerable interest in changes or trends in climate. Trends in summer temperatures are based on the months of June, July and August, and trends in winter temperatures are based on December, January and February. In 63.8% of all years July is the warmest month, in 27.6% August is warmest, and in 8.6% June is warmest. In winter the coldest month occurs in December 39.6% of all years, in January 39.6% of all years, and in February 20.7% of all years. When graphed, both summer and winter trends show an approximately 20-year cycle of rises and dips with each coinciding in the same decades for both seasons. In both seasons the decade of the 1950's was the warmest and the decade of the 1960's the coldest.

PHYSICS AND MATHEMATICS

SIMPLE DOPPLER EFFECT EXPERIMENT WITH MICROWAVES

Phillip Chadbourne and H. T. Tohver. Dept. of Physics, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

A belt-driven pin inside a waveguide acts as the moving target for 10 GHz microwaves generated by a Gunn diode. The incident and reflected signals are mixed in a standard microwave point-contact detector. The output frequency of this highly non-linear detector yields the Doppler frequency shift directly. The experimental errors are less than 0.5%.

PARAMAGNETIC RESONANCE STUDIES OF ALKALINE EARTH OXIDES

W. E. Plott and H. T. Tohver. Dept. of Physics, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The general features of a newly discovered lithium pair defect in MgO are described. The substitutional lithium ions are oriented along the $\langle 001 \rangle$ directions separated by an O^- ion. A distortion of this linear chain in any of the perpendicular $\langle 010 \rangle$ directions has also been noted.

Abstracts

DETERMINATION OF THERMAL EQUILIBRIUM TIMES OF THERMOCOUPLES

W. J. Atkinson. Dept. of Physics, Univ. of Ala., Birmingham, AL 35213.

The temperature distribution of a tumor in hyperthermia treatment determined from thermocouple measurements may be quite different from the distribution before inserting the thermocouple. In hyperthermia, heat transfer to the tumor and between the tumor and the thermocouple is governed by the heat diffusion equation. From this equation, the temperature distribution before and after inserting the thermocouple can be determined and the two distributions compared. Due to the complex geometry of the thermocouple and the asymmetry of the heat sources, the diffusion equation, in general, must be solved by finite difference methods. Thus the program BRIXY has been developed on the PRIME computer. BRIXY solves the two dimensional diffusion equation in (x,y) coordinates within an arbitrary closed surface, heat source function and variable thermal conductivity with the Dirichlet condition subjected to the boundary surface. Cases are yet to be analyzed using BRIXY.

A NEW SET OF INTEGRAL EQUATIONS FOR THE THREE-BODY PROBLEM

Shoa-Hua Chao. Dept. of Physics, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The three-body problem for a nonrelativistic spinless three-particle system is considered. The difficulties and properties of both the Faddeev and Osborn-Wilk equations are discussed. An alternative to the Faddeev equations is made in the momentum representation. The new equations have similar structure to those of the Faddeev equations and involves on the physical quantities.

THE $^{51}\text{V}(n,\alpha)^{48}\text{Sc}$ AND $^{54}\text{Fe}(n,2n)^{53}\text{Fe}$ REACTIONS AT 14.2 MeV

W. H. Warren and W. L. Alford. Dept. of Physics, Auburn Univ., Auburn, AL 36830.

Cross section measurements for the production of charged particles and neutrons by 14 MeV neutrons incident on vanadium and iron are of interest for the possible use of these elements as structural materials in fusion reactors. In the present work the $^{51}\text{V}(n,\alpha)^{48}\text{Sc}$ and $^{54}\text{Fe}(n,2n)^{53}\text{Fe}$

Abstracts

reaction cross sections have been measured by activation techniques for 14.2 MeV neutrons from the ${}^3\text{H}(d,n){}^4\text{He}$ reaction. Samples of 99.9% pure V_2O_5 and Fe were positioned for irradiation at 81° with respect to the direction of the 0.333 MeV incident deuteron beam produced by the Auburn University Dynamitron accelerator. The neutron flux was determined by counting the associated alpha particles. A 16% Ge(Li) detector of known photopeak efficiency was used to detect the gamma ray activity of the residual nuclei. Results accurate to about 8% give cross section values of 5.1 mb for the ${}^{54}\text{Fe}(n,2n){}^{53}\text{Fe}$ reaction and 16.2 mb for the ${}^{51}\text{V}(n,\alpha){}^{48}\text{Sc}$ reaction.

SOLUTIONS OF THE BIOHEAT TRANSFER EQUATIONS RELATED TO HYPERTHERMIA FOR TUMOR THERAPY

Alan Harmon. Dept. of Physics, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The bioheat equation has been solved under conditions which simulate the treatment of tumors when heated by high frequency electromagnetic waves. The solutions yielded give a temperature profile for a spherical region in which different tissues are simulated by known physical parameters such as blood flow and conductivity. This model provides some insight into proper techniques for effective treatment. Certain difficulties are encountered with tumor size, occurrence of fatty tissue, etc., and it is hoped that this model will allow a prediction of the usefulness of hyperthermia in consideration of these difficulties.

PRODUCTION OF CANDIDATES FOR THE DIFFUSE INTERSTELLAR BANDS

Thomas J. Wdowiak. Div. of Natural Sciences and Mathematics, Miles College and Dept. of Physics, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

A method of synthesis via plasma discharge and rare gas cryogenic matrix isolation has produced large carbon containing molecules from a 0.5 percent methane in argon mixture, giving rise to a reproducible system of features corresponding to diffuse interstellar bands (DIB's), including the strongest and widest 4430 (4428)A diffuse interstellar band, the second strongest and wide 6283 (6284)A DIB along with its narrower and shorter wavelength companion, the 6269A DIB, and the 5778-5780A DIB's. All features appear in the same experimental run, but because of matrix effects are shifted slightly from their observed interstellar wavelengths. Their strengths, widths, profiles, and mode of synthesis including two- and three-carbon precursors, argues strongly for their correlation with the natural DIB features, and for the hypothesis that the DIB's are produced by polymeric carbon species. Importantly, the laboratory produced spectral features are stable under irradiation of ultraviolet light produced by a mercury vapor lamp.

Abstracts

INDUSTRY AND ECONOMICS

URBAN AGRICULTURE: PRESENCE, POTENTIALS, AND PROBLEMS

Steven R. Sax, Planning Director, NACOLG. H. A. Henderson, Agricultural Economist, TVA.

Preserving the nation's food producing capacity is of increasing concern to the public according to recent national surveys. The public increasingly prefers land to be preserved for producing food rather than other uses. In the Tennessee Valley, as elsewhere, urban sprawl is well documented. Likewise, the existence of home gardens in cities is known to be common, but little is known about presence of commercial farming in urban areas. This study shows that considerable commercial farming exists in urban areas. For example, within the city of Tusculumbia, Alabama, one-third of the land is in crop or livestock production, and one-sixth of the land is in forest production. Farm sales were \$183,000 and related farm-dependent business activities were \$640,000. Improved land use and improved farming practices could increase farm production to \$1,170,000 and related farm-dependent business to over \$4 million. Existence of substantial farming within the city boundaries raises several policy questions. Some are:

1. Is intermixed farming and urban activities efficient use of resources?
2. To what extent is decreased food production efficiency offset by benefits such as environmental protection and open space?
3. How can the production capacity and environmental values of farming be protected in close association with housing without conflicts.
4. Should city governments develop more positive policies toward agricultural within their boundaries?

NORTH ALABAMA AGRIBUSINESS

Veronica A. Vitelli, W. Joe Free, and Maceo Leonard. Agricultural Marketing Resource Development Section, TVA, Muscle Shoals, AL 35660.

This study examines the extent of agribusiness in the Tennessee Valley area of north Alabama. In north Alabama, sales of 705 agribusiness firms were \$1.2 billion in 1978 or \$1.7 million per firm. This was 1.6 times the estimated sales of all farm products in 1978. Farm sales grew faster between 1972 and 1978 than did agribusiness. Over the 7-year period, farm sales increased 121 percent and agribusiness increased 32.5 percent. In 1978, employment by agribusiness firms was 31,063. Capital investment in 1978 was \$432.4 million, \$613,379 per firm, and \$13,921 per employee. The trade area for north Alabama varied by type of business. North Alabama agribusiness has potential for future growth. In 1978, 43 percent of the firms planned to expand production. Most expansion was planned to occur within 2 years. Twenty-nine percent of the firms planned to expand employment, and 24 percent of these planned the expansion within 2 years. Data accumulated in previous agribusiness studies were used as the basis for projections of agribusiness volume.

Abstracts

Farm sales in the north Alabama counties is expected to be approximately \$900 million in 1985; agribusiness volume is expected to increase to \$1.5 billion in 1985.

THE MANAGEMENT AUDIT--A TOOL FOR MEASURING PERFORMANCE IN AGLIME RETAILING

W. Joe Free. Agricultural Marketing Resource Development Section, TVA, Muscle Shoals, AL 35660. William S. Stewart. Univ. of N. Ala., Florence, AL 35630.

A management audit was conducted for firms in the aglime sector in the Tennessee Valley to identify and help solve financial, logistic, and other problems associated with this farm service oriented industry. Farmers often have problems getting lime applied when needed and spreading services are sometimes poor resulting in erratic distribution patterns across the field. Since lime is a low-profit item and is usually considered as a service to the farmer, aglime firms generally do not promote it or coordinate aglime sales with other farm supply services such as fertilizer application. Therefore, individual firms were audited with special emphasis on aglime retailing (prices, etc.) to determine the manner in which aglime services are conducted in relation to other products and services offered. The audit was conducted for all firms in a county which was defined as the market area and results were used to evaluate performance of the industry in the market area. Results indicate that lime prices to farmers do not cover the firm's cost for providing this service.

THE COMPETITIVE POSITION OF ALABAMA IN THE WOODY ORNAMENTAL MARKET

W. Joe Free and Veronica A. Vitelli. Agricultural Marketing Resource Development Section, TVA, Muscle Shoals, AL 35660.

Production costs of woody ornamentals are lower for nurserymen located in the South compared to those in the North. However, southern nurserymen face higher transport costs in marketing plants in the Northeast and Midwest consuming centers. A preliminary indicator of the regional advantage for Alabama nurserymen can be shown by comparing estimated wholesale prices in Alabama plus transportation charges with wholesale prices received by competitors in the Midwest and Northeast. A high positive price differential between production plus transport costs and wholesale prices in the consuming center suggests a regional advantage for Alabama nurserymen. Production budgets for Kurume Azaleas were used to illustrate the relative regional advantage of Alabama producers in the woody ornamental market. Higher wholesale prices in the North more than offset the additional cost of transportation from Alabama to these markets. Higher price differentials for the Northeastern market (Boston and New York) than for the Midwestern market from both Alabama supply points (Mobile and Huntsville) indicate a regional advantage for Alabama nurserymen in the Northeastern markets.

Abstracts

PUBLIC SECTOR EMPLOYEE-EMPLOYER RELATIONS IN ALABAMA

George Munchus III. Dept. of Business Administration, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

This paper provides an exploratory analysis of the past, present, and future trends in public sector labor-management relations in the State of Alabama. The legal and legislature framework for collective bargaining is discussed, as well as the extent of union organization and data on lost time (work stoppages) due to labor-management disputes. A cursory review of some public sector disputes, negotiations, and settlements are discussed. Court decisions, where appropriate have been included as there is an expressed absence of statutory law regulating public employee-employer relations in the State of Alabama. A prognosis of future developments in this area is made as well as the impact the political process has had on union-management development in the public sector.

THE FUTURE OF THE RURAL LANDSCAPE: PRESERVATION OR ANONYMITY?

Robert C. Walker, Jr. AICP.

The "American Frontier" and now rural America has served throughout this country's history as a "safety valve." Early settlers could always go there when they were dissatisfied with the growing cities, taxes, and government. Our traditional American values have thrived in rural America; i.e., rugged individualism, self-reliance, and the peaceful co-existence with nature. Today in most of the South (and until recent years, the entire States), there are no "enabling laws" that allow planning for growth and development. The current "decision making process" that governs growth and development in rural areas is piecemeal, with no thought of the long-range consequences. An inherent and tragically ironic problem is that the very reason most rural people oppose land use planning is the same reason they are subject to and are victim of a myriad of insensitive and controlling interests. The "rural value system" perpetuates the non-concern for the future of the quality of life of the countryside. Rural areas are the last bastion of the traditional values upon which America was founded. Do we maintain the rural landscape as a sanctuary for the crowdedness, anxieties, phobias, and pollution of our urban areas? Or, do we allow urban sprawl to continue to spread into our rural areas, changing them forever? Do we allow there to become no distinction between "rural" and "urban"? This paper presents a strategy for the motivation and awareness of "the people" through a *controlled* crisis. The issue before us that is just becoming a "crisis" is *The Endangered Future of the Tennessee River*. If a "rural planning process" can be established, it will be more effective if developed by the people. The effort has to emphasize and embody this philosophy: The real issue is to plan for and to guide *sensible* growth--not to stop growth--and not to control property rights.

Abstracts

SCIENCE EDUCATION

FALCON FORCE: A NEW AEROSPACE SCIENCE PROGRAM

Ernest D. Riggsby and Dutchie S. Riggsby. School of Education, Columbus College, Columbus, GA 31907.

Falcon Force is a middle school, interdisciplinary approach to the teaching of aerospace science. Developed in kit form, the program is divided into eight "forces" or sub-units:

- Principles of Flight
- Weather
- Airplanes in the World Community
- Flight: People, Machines, and Events
- Spacecraft
- Aerospace Communications
- Aerospace Art
- Aerospace Odyssey: The Future

The kit includes: subject matter narrative, activities, student resources, and a teacher's resource guide. A 120-school, nationwide pilot study and validation program is currently underway. When the pilot study is completed, and necessary revisions accomplished, the kit will be made available to interested teachers, schools, and instructional resource centers. The *Falcon Force* kit was produced under the sponsorship of the Civil Air Patrol, well known non-profit service organization--one of whose missions is to stimulate and support aerospace education in the nation's schools. The cost of the kit will be kept to an absolute minimum.

COMMUNICATING THROUGH PHRASES AND GESTURES

Wilbur B. De Vall, President. Proxy Services, Ltd., Auburn, AL 36830.

People communicate their thoughts through music, art, literature, drama, and the spoken word. Daily we communicate through the spoken and written word as a way of life. How effective we are depends on the meaning the other person receives through our choice of words and actions. Individual words may have dual or multiple meanings. Words when combined into phrases may become descriptive or meaningless in the minds of the reader or hearer. Gestures, when combined with phrases, convey to an audience or an individual something about an individual. This may be interpreted as sincerity, flaunting one's ego, or merely an expression of superiority. Phrases and gestures in every-day use among people, by speakers before an audience, or by personalities appearing on the television screen, have been studied and recorded over a period of two years and are described in the context of "meaningless phrases" and "egotistical" gestures. While in every-day use, the phrases and gestures described indicate that individuals should study their own habits with the goal in mind of becoming better and more sincere communicators.

Abstracts

SOCIAL SCIENCES

EARLY SCOTTISH FARMING: A STUDY IN RETARDATION

Kenneth R. Wesson. Dept. of History, Univ. of Ala., University, AL 35486.

The modernization of Scottish agriculture has been applauded many times--a story of subsistence and profit being realized from an uncooperative environment. This achievement tends to overshadow the genesis of agricultural progress in Scotland. Yet the Scots' blind adherence to the methods of their forefathers prevented progress for many decades, and the Celtic system endured relatively intact until the mid-18th century. Early Scottish agriculture was dependent on the exhaustion of virgin soils. For as long as land was abundant, and people few, no rotation of crops was needed; fresh land was plowed each year. Only when the population had increased and settlements made permanent did farmers employ methods which restored the fertility of the soil. Maximum rainfall, minimum sunshine, and the lack of proper drainage caused the dry uplands to be occupied and cultivated first, while the rich valleys of forest growth remained uninhabited and untilled. In addition to the climatic barrier, great stretches of Scotland were natural regions of poverty. More than 3/5 of the land is mountain, moor, or hill, and of Scotland's 19 million acres only 5 were fit for cultivation in the early 19th century. This situation led to prolonged deterioration of the land. Thus a brief recapitulation of the beginnings of Scottish farming serves to enhance the progress achieved in Scotland, and to better understand that country's great agricultural struggle.

JOHN à LASCO: A POLISH RELIGIOUS REFORMER IN ENGLAND, 1550-1553

Richard Glen Eaves and William A. Carter. Dept. of History, Auburn Univ., Auburn, AL 36830.

John à Lasco became a prominent figure in the English Reformation movement from 1500 to 1553. This Polish nobleman, also known as Jan Laski, travelled a long and circuitous route from his birth at Lask castle in Poland in 1499 to his role as a leader of religious exiles in England during the reign of King Edward VI. Lasco and his family arrived in England in early May 1550 and were naturalized as English citizens by a royal charter on 27 June 1550. The influx of foreign refugees who had fled from Catholic persecution on the continent created a need for religious services in their own languages and led to the establishment of the Strangers Church in London. These refugee churches, for example, included Italian, Flemish, Franco-Belgian, and German. It fell to Lasco the task of organizing these various Strangers Churches of different languages and nationalities into some semblance of unity of organization and doctrine. After the death of Edward VI, Catholic Mary Tudor became queen and burned the leading Protestants who did not flee the country. Fortunately, Lasco left, returning to Poland where he died

Abstracts

in 1560. Thus passed from the European scene another one of those many learned second-rank religious reformers without whose labors there could hardly have been a Reformation.

EARLY LIFE OF ROBERT DUDLEY, 1532-1564

Jeanne M. Twiggs. Dept. of History, Auburn Univ., Auburn, AL 36830.

Robert Dudley spent the first thirty-two years of his life in court intrigue under three monarchs of England. He also machinated his way into the international political scene of the sixteenth century. Dudley exercised the most power and influence during the first six years of the reign of Elizabeth I, a period in which he was the queen's most trusted confidant and her most likely candidate as a husband. Dudley's bond with his queen was long-standing and had been bred from mutual suffering during the reign of Mary I. From this suffering emerged a friendship which lasted throughout Dudley's lifetime but saw its peak during the first years of Elizabeth's reign. Robert Dudley began his life the grandson of an executed traitor, and before his twenty-fifth birthday his father was beheaded for treason and Lord Robert himself was in the Tower of London under the same sentence. The son, however, was more fortunate than the father and was released in time to do service to Mary I in a war with France. At the ascension of Elizabeth I, Dudley rose to the top in power and influence, a position he was to relinquish grudgingly and never completely.

JAMES I AND THE PROTESTANT CAUSE IN FRANCE AND GERMANY

Brian M. Wood. Auburn Univ., Auburn, AL 36830.

The defeats suffered by Protestant nations in Europe generated a great deal of sympathy in England. James I, the English king, irritated his people by refusing to take part in continental struggles. James was dedicated to a peaceful solution of the problem through diplomacy. He befriended both Protestant and Catholic nations in an attempt to act as arbiter between them. When his understanding with Spain collapsed, James approached Louis XIII of France. The English King gave up his efforts to maintain peace and declared war on Spain. James felt that he must have the friendship of Louis XIII of France to fight Spain. Relations with the French were complicated by the Huguenot war and by French insistence on Catholic toleration in England. Pressured by popular opinion and against his better judgment, James agreed to give concessions to English recusants. These concessions threatened to create dissension between the crown and parliament. Parliament was confused as to the diplomatic policy of the king and would not understand his dependence on Catholic countries.

Abstracts

EUGENE SCHUYLER ON THE JEWISH SITUATION IN RUSSIA, 1870-75

James S. Brown, Jr. Dept. of History and Political Science, Samford Univ., Birmingham, AL 35209.

Eugene Schuyler, Consul in Moscow and Tallin 1867-69 and Secretary of Legation at St. Petersburg 1870-75, was one of the more capable American diplomats of the century. The United States' first Ph.D. (Yale, 1861), he came to Russia with letters of introduction from Turgenev, whose *Fathers and Sons* he had translated. He was introduced to Russian society through the Moscow salon of Prince V. F. Odoevskii. Many of his contacts with influential Russians and institutions as important as the Geographic Society were initiated here. As Secretary of Legation later he gave U.S. officials their first clear look at the position of Jews in Russia. Most important, he demonstrated how the Empire's Jewish population was being pressured by the spread of slavophile and panslav emotions. Much of his information came from the work of the brilliant Odessa publicist Il'ia Orshanskii. Late in his stay the usually liberal Schuyler came within the orbit of such extreme nationalists as V. V. Grigor'ev, Central Asian expert and member of a governmental commission for Jewish affairs. Much impressed by Grigor'ev in other areas, Schuyler may have been influenced by Grigor'ev's ideas on the Jewish "problem" in Russia.

THE IMPACT OF STRUCTURE ON EXECUTIVE POWER IN AN ALABAMA CITY GOVERNMENT: THE AUBURN EXPERIENCE

Don E. Hayhurst. Dept. of Political Science, Auburn Univ., Auburn, AL 36830.

Many scholars believe the greatest weakness in American government is the failure to grant executives power commensurate with responsibility. The plural executive in Auburn City Government results in a division of executive authority which virtually destroys all political accountability. The City has a mayor-council form of city government with a city manager. Title 37, Section 418 of the *Code of Alabama* authorizes all state cities "at their discretion" to hire a city manager whose term expires with the term of the city council which appoints him. Auburn is one of approximately six cities which presently employ a manager, who is a retired army officer. Thus, the appointed manager, whose powers are provided in the *Code*, serves as "administrative head," and the popularly elected mayor is "executive head" of the city's government. The result is a two-headed monster, which the mayor characterizes as a bastard form of city government. The appointed official has the administrative authority, and the elected official has the political responsibility to the electorate. Whereas citizens' expectations of the mayor are high, he is largely impotent. The political environment of the city manager and mayor, and the interaction of their roles, results in an appointive official who possesses administrative powers of city government and who is very largely invisible and inaccessible to citizens, and the elected executive who is largely powerless, totally visible, and accessible to all. Political accountability, frustration and turmoil are the inevitable casualties of this bastard form.

Abstracts

CAVEAT EMPTOR: ADVERTISING PATENT MEDICINES IN HUNTSVILLE AND MADISON COUNTY

Marsha K. Marks. Dept. of History and Political Science, Ala. A.&M. Univ., Normal, AL 35762.

How to stay well, recuperate from illness and live happily ever after was even more of a problem during the 1880's in Huntsville than it is today. It is important and interesting to view everyday life in Huntsville, to find out how people in Madison County coped with the problems of life. One of the best ways to view earlier days is through the local newspapers, for they generally reflect what local conditions were like. From 1881 to December 29, 1894, Huntsville and Madison County's Black population was served by the Huntsville *Gazette*. A study of its advertisements reveals many a pitfall for the unwary reader. The optimism of the time was evident in the patent medicine advertisements, which stressed the wide range of coverage of their products and their quick results.

PERSISTENCE OF FARM HOUSEHOLDS: ALABAMA, 1850 TO 1860

Henry Inman. Dept. of Biostatistics, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Traditionally, historians have viewed migration in the antebellum South as a process of displacement of farmer by planter. The wealthiest slaveholders and the poorest nonslaveholders persisted, while farm households between these extremes migrated. To determine whether the migration of Alabama farm households between 1850 and 1860 followed this pattern, a sample of 658 Alabama farm households was selected from ten counties in the 1850 manuscript census. The persistence of a household in the sample was established by consulting the 1860 census. The rate of persistence for the entire sample was 50.9 percent. For slaveholders, the rate of persistence was 56.6 percent; for nonslaveholders, 46.9 percent. The slaveowning farm households which persisted from 1850 to 1860 were, on the average, wealthier, derived less of their farm product from cotton, and were more self-sufficient in corn than their migrating counterparts. For nonslaveowning farm households, the persistent households were, on the average, wealthier and more self-sufficient in pork than their migrating counterparts. There was no significant difference in the size of slaveholdings between persistent and migrant slaveholding farm households. The persistence of the Alabama sample follows a pattern that was characteristic of migration in nineteenth century America: the wealthy tended to persist, the poor tended to migrate. The rates of persistence for slaveholders and nonslaveholders, while significantly different, were not unusual when compared to the rates of persistence for other populations in the United States.

Abstracts

A SHORT HISTORY OF THE JEWISH PEOPLE OF BIRMINGHAM

Henry S. Marks. Dept. of History, N.E. State Junior College, Rainsville, AL 35986.

Birmingham shares with Miami, Florida, a uniqueness in the South and perhaps even in the nation concerning its Jewish population. These are the only two cities in the South where Jewish people were present at their incorporation and pioneered in their early growth and development. Usually Jewish people have moved into more developed communities and consequently are never so closely identified with their early history. Probably the major reason for this uniqueness is that both towns were founded after the Civil War, long after Jewish people became associated with Alabama and Florida.

MEIN KAMPF AND THE AMERICAN COURTS

Joseph Elixon. Dept. of History, Univ. of Ala., University, AL 35486.

During the late 1930's, Americans developed a keen interest in Adolf Hitler and in his book *Mein Kampf*. The work had not appeared in an unabridged English translation before 1939. On December 31, 1938, two American publishers announced plans to provide complete American editions. Reynal and Hitchcock had acquired the right to publish from Hitler's agent, Houghton-Mifflin. The other edition of the book was promised by Stackpole Sons. Stackpole claimed that Hitler's American copyright was invalid and the book was in the public domain. A lawsuit resulted. Houghton-Mifflin sought an injunction to prevent sale of the "pirated" edition. A U.S. District Court heard the arguments, and refused to grant the injunction. Houghton-Mifflin appealed and the Second U.S. Circuit Court of Appeals reversed the district court. The appellate court went further and decided the case. Stackpole's main argument was that stateless persons could not obtain U.S. copyright protection. Hitler had been stateless when he acquired copyright, therefore his copyright was void. The appeals court rejected this argument. The court stretched the meaning of a sentence in the relevant statute to justify the ruling, but the core of the decision lay in the unfortunate consequences of accepting Stackpole's contention. To have ruled against stateless persons would have been contrary to the tradition and ideals of the United States. The court refused to believe that such had been the intent of Congress. Houghton-Mifflin and Adolf Hitler had won a victory for the rights of all authors.

HEALTH SCIENCES

RESPONSE OF PANASONIC PERSONAL AND ENVIRONMENTAL DOSIMETERS

Glenn Hudson. School of Public Health, Univ. of Mich., Ann Arbor, MI 48109.

Panasonic has recently introduced a new type of dosimeter to the field of dosimetry. This dosimeter, composed of $\text{Li}_2\text{B}_4\text{O}_7:\text{Cu}$ and $\text{CaSO}_4:\text{Tm}$ has

Abstracts

been extensively studied at the University of Michigan. The radiation type response, fading and linearity have been documented so that the dosimeter can now be used in mixed radiation fields with accuracy.

INFLUENCE OF INDOMETHACIN ON TERATOGENICITY OF RETINOIC ACID

Anne Moreland Cusic. Dept. of Biology, Univ. of Ala. in Birmingham, Birmingham, AL 35294. S. D. Harrison, Jr. Southern Research Institute, Birmingham, AL 35205. E. Paul Denine. Southern Research Institute. C. P. Dagg. U.A.B.

Studies have shown that indomethacin reduces the toxicity of retinoic acid in adult mice (Hixson and Denine, '78). This interaction is now being studied in mouse embryos. All-trans retinoic acid (RA) was administered orally on Day 9 of pregnancy at a dose of 100 mg/kg to ICR/SAF mice. Indomethacin was given orally at a dose of 8 mg/kg, one hour prior to RA. Animals were sacrificed on Day 17 and the fetuses were examined. RA caused 98.8% of the fetuses to be malformed. The defects included cleft palates, tail abnormalities, imperforate anus, facial dermal tabs, kidney and bladder malformations. The combination of RA and indomethacin produced 87.5% malformations. The combination induced the same types of anomalies as RA, alone. In the combination dosed animals, there was a decrease in cleft palate and tail malformations. However, an increase in percentage of defects was observed in the eyes, kidneys and bladders. An increase in dermal tabs and imperforate ani was also seen in the combination treatment. There was no difference observed in the number of resorptions between the two groups. Supported in part by contract N01-CP 22064 from the Division of Cancer Cause and Prevention, National Cancer Institute.

DEVELOPMENT OF CULTURED AND TRANSPLANTED EMBRYONIC GONADS

Gregory Cameron and C. P. Dagg. Dept. of Biology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The capacity of male genital ridges to form teratomas when transplanted to the testes of histocompatible adult hosts has been well established by Stevens. However, this capacity is lost after day 13 of gestation. To test for possible causes of this loss, 12 and 13 day old genital ridges were placed in organ culture for 24 to 28 hours prior to transplantation to suitable adult hosts. All donor embryos and adult hosts were F₁ hybrids of inbred strains 129/SvSl +/- and A/He mice. The genital ridges were cultured at 37°C, 31°C or 37°C in the presence of 5-Bromodeoxyuridine. While the tissue survived the culture period quite well as determined by histological examination, the incidence of teratomas was drastically reduced. Of the 52 experimental grafts examined histologically, 27 were identified as testes, 11 as ovaries and the sex of 14 could not be determined. Of the experimental testes grafts, only one developed a teratoma (3.7%) as compared to 80% for 12 day control testes grafts and 44% for 13 day control testes grafts. Many of the treated grafts formed well developed duct systems and large cavities lined with

Abstracts

either columnar or squamous epithelium. The germ cells of the ovaries seem to survive the treatment better than the germ cells of the testes. Most of the treated testes grafts appeared to be void or nearly void of germ cells while the germ cells of the treated ovaries were quite evident and many of the ovary grafts contained developing oocytes.

EFFECTS OF CENTRAL 6-HYDROXYDOPAMINE LESIONS ON BODY WEIGHT AND BEHAVIOR IN THE DIABETES MOUSE

Mary A. Pelleymounter and Joan F. Lorden. Dept. of Psychology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Recent work has shown that central catecholamine depletion by intraventricular infusion of 6-hydroxydopamine (6-OHDA) in the obese, hyperphagic and hyperglycemic diabetes (db/db) mouse results in a significant and sustained weight loss and in decreased blood glucose levels. Since this effect of 6-OHDA can be blocked by pretreatment with desmethylimipramine (DMI), a noradrenergic uptake blocker, a defect in central norepinephrine (NE) levels may be linked to the diabetes syndrome. The present study evaluated some of the behavioral and physiological factors that might contribute to weight loss following central 6-OHDA lesions. Diabetes mice with intraventricular 6-OHDA lesions were compared with a db/db vehicle group and with 6-OHDA treated and vehicle treated lean littermates for weight loss, activity level, body temperature, 24-hr food intake, blood glucose levels and adiposity. 6-OHDA db/db mice showed a significant weight gain. Activity levels were significantly lower in both db/db and lean 6-OHDA treated mice. Body temperature was significantly lower in 6-OHDA db/db mice than in db/db vehicles. In addition, 6-OHDA db/db mice ate significantly less than db/db vehicles. 6-OHDA db/db mice also showed reduced blood glucose levels and body fat. Large mean telencephalic and hypothalamic (48% and 83%, respectively) NE depletions were induced by 6-OHDA lesions. Significant dopamine depletion (56%) was found in telencephalic sections only. The results suggest that the weight loss produced by 6-OHDA lesions in the db/db mouse may be due to decreased food consumption. Furthermore, weight loss is due, in part, to loss of body fat.

EFFECTS OF LESIONS OF THE DORSAL NORADRENERGIC BUNDLE OF THE RAPHE NUCLEI ON CONDITIONED TASTE AVERSIONS IN THE RAT

William B. Nunn and Joan F. Lorden. Dept. of Psychology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Lesions of the raphe nuclei which deplete forebrain serotonin (5HT) enhance the acquisition of a conditioned taste aversion (CTA) in the rat. Pretreatment with the 5HT precursor 5-hydroxytryptophan or the 5HT uptake inhibitor fluoxetine attenuates taste aversion learning in normal rats. However, the site at which these pretreatment effects are exerted is unclear. In order to determine if the site of action is central 5HT neurons, we compared the effects of forebrain 5HT depletion to the effects resulting from administration of either fluoxetine or the NE uptake

Abstracts

inhibitor desipramine (DMI). Animals with raphe, dorsal noradrenergic bundle (DB) or sham lesions were acclimated to a 23h water deprivation schedule. When fluid intake during the first 10 min of water presentation had stabilized, taste aversion training was begun. A third of the subjects from each lesion group received intraperitoneal injections of fluoxetine (10 mg/kg), DMI (10 mg/kg) or saline. One hour later a sucrose (5%) solution was presented for 10 min and followed immediately by an ip injection of lithium chloride (12 ml/kg, .15M). Measurement of forebrain amine levels verified the depletion of 5HT in the raphe group and of NE in the DB group. All lesion groups learned an aversion to sucrose. The pretreatment effects obtained with fluoxetine were more pronounced than those obtained with DMI; however, no evidence was found to support the conclusion that pretreatment effects are specifically dependent on intact forebrain 5HT neurons.

TERATOGENESIS AFTER CO-ADMINISTRATION OF URETHANE AND CAFFEINE

Janice W. Roberts. Dept. of Biology, Univ. of Ala. in Birmingham, Birmingham, AL 35294. L. W. Yielding. Laboratory of Molecular Biology, U.A.B. H. D. Giles. Southern Reserach Institute, Birmingham, AL 35205. C. P. Dagg. U.A.B.

Ethyl carbamate (urethane) is a well documented teratogen in mice. Evidence indicates that urethane is a DNA-damaging agent. Caffeine is reported to be an inhibitor of DNA repair and has been shown to enhance X-ray induced birth defects but not gamma ray induced defects (Yielding et al., 1976). Nomura, 1977, reported that treatment with caffeine before urethane injections on day 9 of gestation in mice increased the incidence of cleft palate and tail defects but decreased polydactyly. When caffeine treatment followed urethane treatment, the incidence of all three malformations decreased. Preliminary studies in our laboratory using an ICR/SAF mouse line indicated that from days 8 through 11 of gestation, day 9 was the most sensitive for urethane induced malformations, with cleft palate, limb and tail defects being most common. Caffeine (50 mg/kg) was injected subcutaneously at 6 hour intervals from -30 to -6 hours before, or from 0 to 24 hours after injecting 1 mg/g urethane subcutaneously on day 9. Pretreatment with caffeine increased the incidence of tail defects but not cleft palate or limb malformations. Post-treatment with caffeine decreased the incidence of cleft palate and tail defects but had no effect on limb malformations.

EXTREME VALUE THEORY OF VOLUME EFFECT IN RADIATION ONCOLOGY

Donald E. Herbert, Jr. Dept. of Radiology, Univ. of S. Ala., Mobile, AL 36688.

It is commonly observed in the study of the strength of materials that the larger specimens will fracture under less applied stress, break down under less applied voltage, corrode in a shorter time, etc. The statistical theory of extreme values provides a rational explanation of this "size effect." This theory describes the relation which exists between

Abstracts

the parameters of the frequency distributions of the extreme values (smallest, $x(1)$, and largest, $x(n)$) in a sample from a population of observations x_i and the sample size, n . It can be shown that the location, scale, etc., parameters of the frequency distributions of extreme values are functions of sample size and that as the sample size increases the frequency distributions of smallest and largest values of x in the sample are shifted to smaller and larger values of x , respectively. There are cognate "size effects" in clinical radiation oncology: complications of normal tissue occur more readily at larger field sizes for a given dose and recurrence of disease is observed more frequently from the larger tumors for a given dose. It is shown that these clinical phenomena are not inconsistent with the statistical theory of extreme values. It is shown that this theory provides a heuristic description of the observed decrease in probability of uncomplicated control as the target volume increases. Comparison of the predictions of this theory with accepted clinical observations on the volume effect are presented. This agreement between these observations and the predictions of the theory is quite good. "It is a truism of which the mathematical consequences are of no little interest, that the strength of a specimen is that of its weakest link."

THE EFFECTS OF SYSTEMIC CANDIDIASIS ON LYMPHOID TISSUE

Edward A. Sass, Zoe A. Evans, and Junius M. Clark. Dept. of Biology, Univ. of Ala. in Huntsville, Huntsville, AL 35807.

Six week old male Swiss Webster mice were used to study the effects of systemic *Candida albicans* infections. Mice injected intravenously with 1×10^6 *Candida* yeast cells developed infections which were fatal within 15.7 days. For the first 9 days after challenge thymus weights of infected animals decreased significantly when compared to weights of saline control animals. The peripheral blood showed an increase in atypical lymphocytes accompanying thymic involution and splenomegaly. Beginning at day 9, the thymus mass increased until the weight of the thymus of the infected animals approximated the weight of the saline control animals at day 14. Adrenalectomized Swiss mice challenged with 1×10^6 cells showed an increased mean survival time over the intact animals but showed lymphoid changes similar to those in intact mice. In a separate experiment using adrenalectomized mice, results indicated that a challenge with heat killed *C. albicans* did not produce a significant decrease in thymus weight. The results of these experiments indicate that the thymic involution seen in systemic *Candida* infections is not due solely to a thymolytic effect of adrenal corticosteroids released during the infection, but is due to some mechanism associated with actively growing *Candida* infections.

Abstracts

CHRONIC STREPTOCOCCAL INFECTION IN THE MOUSE

J. M. Clark and Z. A. Evans. Dept. of Biology, Univ. of Ala. in Huntsville, Huntsville, AL 35807.

Group A Streptococci have been implicated in numerous disease processes such as rheumatic fever and arthritic states. Retention of bacterial cell wall material by phagocytic cells has been suggested as a possible mechanism for some pathologic processes. Recently a specific antigen has been associated with Streptococci implicated in glomerulonephritis. We have studied the interaction of Streptococci with connective tissue elements of Swiss Webster mice. A connective tissue air pouch was formed in each animal and injected with 10^4 viable bacteria. Connective tissue samples were taken at varying intervals and examined for presence of viable organisms and retention of bacteria within connective tissue cells. Viable bacteria have been recovered from connective tissue air pouches at 104 days postinfection. Material resembling bacterial cells was observed in connective tissue fibroblasts for the length of the experiment. Local accumulations of inflammatory cells were present in the tissue possibly attracted by the presence of bacterial cells within fibroblasts. To facilitate the study of fibroblast interaction with bacteria, connective tissue samples were digested with hyaluronidase in order to free cells from the ground substance matrix and these cells examined by electron microscopy. Intracellular material resembling bacteria was noted in fibroblasts from infected animals and was not present in cells from control animals. It is postulated that connective tissue fibroblasts ingest Streptococci but cannot kill the bacteria and thus serve as a cellular reservoir to maintain a chronic infectious process in mice.

NEMALINOSIS--A FATAL MYOPATHY

Mary A. Dudley and Alden W. Dudley, Jr. Dept. of Pathology, Univ. of S. Ala., Mobile, AL 36688. Normal B. Ratliff, Jr. Dept. of Pathology, Univ. of Minn., Minneapolis, MN 55455. William M. Bridger and Stephen R. Bryan. Baptist Hospital, Montgomery, AL 36111.

A 5 year old male was admitted in respiratory distress, a condition recurring over a seven month period. A sister expired one year earlier with a similar acute respiratory failure at age 5 years. This patient was evaluated at another medical school in Alabama for several months with intensive investigation of possible pulmonary, CNS, cardiac, or immune deficiencies or cystic fibrosis. All tests, including cardiac catheterization, were normal. This admission was characterized by progressive CO_2 retention while asleep leading to CNS depression and stupor. Positive pressure respiration corrected the blood gasses but oxygen catheters did not. The patient was generally able to maintain a normal physiologic state when awake. Aspiration of food was common and caused pneumonia on multiple occasions. He died 5 weeks after admission of fulminating septicemia due to antibiotic resistant *Serratia marsescens*. Muscle biopsy one week prior to death revealed 100% degeneration of 95% of the fibers and 60-95% degeneration of the remainder. The sarcomere

Abstracts

pattern had been destroyed and disoriented due to the elaboration of lattice crystals from the Z-lines. Nemaline (thread) rods have been described in a much lower incidence in many patients with muscle disease. They can be induced experimentally, can appear in the heart, and can be analyzed by laser diffraction optics on EM negatives. They do differ slightly from Z-lines per se.

CENTRONUCLEAR (MYOTUBULAR) MYOPATHY--REPORT OF A KINDRED

Alden W. Dudley, Jr., Fritz A. LaCour, Jr., Brenda J. Shaw, Martin K. Bodden, and James E. Hassell. Depts. of Pathology, Neurology, and Surgery, Univ. of S. Ala., Mobile, AL 36688.

A 52 year old mother and five children of both sexes aged 12 to 27 all show varying degrees and patterns of expression of an autosomal dominant disease of muscle. The clinical weakness is usually so slowly progressive as to have been described as congenital and non-progressive. The histologic appearance resembles myotubes in culture and in the embryo. Type 1 fibers are smaller than Type 2 but Type 2 may disappear to be replaced by adipose tissue. Electron microscopy shows separation of myofibrils by lipid droplets and fluid. The fibrils are small in the center of each fiber and the filaments within the I-band are loosely aligned. The center of the fiber is occupied by a single nucleus, or if transected between nuclei, by mitochondria, lysosomes, glycogen, or lipids. The 25 yo son has formed pools of granular material possibly derived from myofilaments; the 27 yo daughter has large numbers of intercellular droplets resembling non-bound lipids; and the 52 yo mother has formed a honeycomb of basement membrane around each muscle fiber with the spaces containing acid phosphatase-depleted lysosomes. The relationship of these findings to other reported cases and to myotonic dystrophy will be discussed. The biology of muscle as a tissue will be explored and the contributions of clinical material to the study of muscle will be made evident.

EFFECTS OF NEONATAL MONOSODIUM GLUTAMATE TREATMENT ON THE FEEDING BEHAVIOR OF THE MOUSE

Anita Caudle, Leigh G. Greeley, and Joan F. Lorden. Dept. of Psychology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Administration of repeated doses (from 2 to 4 mg/g of body weight) of monosodium L-glutamate (MSG) to neonatal mice produces a syndrome characterized by adiposity and a reduction in lean body mass. Levels of pituitary and target gland hormones are also altered. As adults, MSG-treated mice are hypophagic, hypothermic and hypoactive. MSG produces a lesion which is focused on the arcuate nucleus of the diencephalon; however, at the doses used in most behavioral studies, lesions in a variety of other brain structures occur as well. The present study was conducted to determine the minimum dose of MSG necessary to produce measurable behavioral change. On the fourth neonatal day 33 female albino mice received single injections of 1, 2 or 4 mg/g of body weight of

Abstracts

MSG or of an equivalent volume of .9% saline. In adulthood, food intake was measured at different environmental temperatures and in response to 24h food deprivation. Intake was also measured during the light and dark phases of the circadian cycle. The 2 and 4 mg groups were hypophagic in comparison to the saline controls; however, there were no significant differences in the day:night feeding ratios. Deprivation increased the intake of all groups; but the increment was significantly smaller in the 14 mg group. In response to one week's exposure to a temperature of 17°C all groups except the 4 mg group showed a significant increase in food intake. One week's exposure at 30°C, however, suppressed intake in all groups. Measures of locomotor activity also indicated that only the 4 mg group was significantly hypoactive; but there were no significant differences in body weight. Future studies will be designed to correlate the extent of neural damage with the behavioral changes observed.

THE ROLE OF MACROPHAGES IN RESISTANCE TO HERPES SIMPLEX VIRUS TYPE-1 INFECTION

Mark E. Keating, Wayne L. Gray, and William B. Davis. Dept. of Microbiology and Immunology, Univ. of S. Ala., Mobile, AL 36688.

As initial experiments to investigate the distinction in virulence between herpes simplex virus (HSV) type 1 and type 2, the ability of HSV-1 to infect peritoneal macrophages from Balb/C mice was studied by transmission electron microscopy and *in vitro* plaque assays. Peritoneal exudate cells were first obtained from young adult mice by lavage and macrophages were separated by adherence. The resulting monolayers were examined by electron microscopy following fixation with 2.5% glutaraldehyde in 0.1 M cacodylate buffer (pH 7.3). The monolayers were predominantly macrophages and actual penetration of the virus into the cell was observed. However, when compared to virions seen in highly susceptible Vero cell controls, the vast majority of virions in the macrophage nucleus were incomplete in that they lacked electron dense cores. Further, HSV-1 also caused a significant alteration of the normal morphology of the macrophage. Plaque assays to determine the level of infectious virus at varying times following HSV-1 infection of the macrophage revealed that there was a steady decrease in the amount of virus with less than 5% being recoverable at 24 hours. Thus these studies confirm that HSV-1 infection of macrophages results in an abortive replicative cycle. It also appears that the macrophage in its normal physiological state is sacrificed in the process.

NATURAL CELL-MEDIATED CYTOTOXICITY IN THE HAMSTER

Donna Walker and Robert N. Lausch. Dept. of Microbiology and Immunology, Univ. of S. Ala., Mobile, AL 36688.

The role of natural killer (NK) cells in host resistance to virus infection is being studied using hamster lymphoid cells in the ⁵¹chromium release test. We have found that normal LSH strain peripheral blood

Leukocytes (PBL) are cytotoxic for herpes simplex virus (HSV) type 1-infected syngeneic fibroblasts at effector to target cell ratios as low as 5:1. In contrast, uninfected target cells were not lysed. NK activity was also manifested by spleen and bone marrow cells but little or no cytotoxicity was obtained with lymph node or thymus cells. PBL from inbred hamster strains MHA and F1B as well as the outbred LVG strain killed allogeneic-infected cells. In addition xenogeneic target cells were also killed. Thus, the cytotoxicity was not histocompatibility restricted. Vaccinia-infected cells were substantially more resistant to lysis. Additional viruses are being studied in order to more fully evaluate the specificity of the cytotoxicity. Preliminary characterization of the effector cells in peripheral blood indicated that they are nonadherent and resistant to 900 R irradiation. NK activity is not blocked or enhanced by anti-HSV antibody suggesting (a) that the target antigen may not be a virus-induced membrane antigen, and (b) that antibody-dependent cellular cytotoxicity is not the mechanism of kill.

ACTIVE-SITE-DIRECTED ALKYLATORS OF HISTIDINE DECARBOXYLASE

Roger S. Lane. Dept. of Biochemistry, College of Medicine, Univ. of S. Ala., Mobile, AL 36688.

The substrate analogs 2-bromoacetamidopyridine (2-BAMPyr) and 3-bromoacetylpyridine (3-BAP) have been synthesized and tested as potential active-site-specific alkylating agents for histidine decarboxylase (HDC) from *Lactobacillus 30a*. Both reagents bind reversibly to the histidine-binding site at pH 5 (pH opt) and irreversibly inactivate the enzyme at pH 7. Experiments using 2-bromo[1-¹⁴C] acetamidopyridine show that loss of HDC activity is directly proportional to incorporation of [¹⁴C] label and correlates with the alkylation of 5 cysteinyl residues per protein molecule (1 SH/active site). Complete inactivation of HDC by 3-BAP is also associated with the selective modification of 5 sulfhydryl groups. However, different kinetic profiles for inactivation are observed with the two affinity labels. With excess 2-BAMPyr, loss of active enzyme is first-order throughout the entire course of reaction and second-order overall with $k_2 = 10.8 \text{ M}^{-1}\text{min}^{-1}$. In contrast, inactivation by 10 mM 3-BAP is biphasic; each phase follows pseudo-first-order kinetics with half-lives of 32 and 19 min which are independent of enzyme concentration. The first (slow) rate of inactivation accounts for ca. 20% loss of activity and correlates with 1 SH modified; the second (fast) phase extrapolates to an additional 4 residues modified for complete inactivation. Both inactivation rates obey saturation kinetics: $K_D = 9 \text{ mM}$ and $k_{\text{max}} = 0.04 \text{ min}^{-1}$ (slow); $K_D = 46 \text{ mM}$ and $k_{\text{max}} = 0.23 \text{ min}^{-1}$ (fast). These results indicate that 2-BAMPyr and 3-BAP are effective affinity labels which exhibit absolute specificity for a single SH group within the active-site region of HDC, and further suggest the presence of differentially reactive catalytic sites in this decarboxylase.

Abstracts

PROPERTIES OF CUPROZINC SUPEROXIDE DISMUTASE IN LIVERS OF AGING RATS

Rajendra D. Ghai and Roger S. Lane. Dept. of Biochemistry, College of Medicine, Univ. of S. Ala., Mobile, AL 36688.

The properties of liver cuprozinc superoxide dismutase (SOD) in senescent (32-35 mos.) and biologically mature (9-12 mos.) Fischer 344 rats have been compared in order to test for possible defects in protein structure in cells of aging organisms. The enzymes in old and young liver cytosols were not distinguished on the basis of their: 1) specific catalytic activities at all stages of purification to homogeneity; 2) catalytic activities per unit of enzyme antigen as determined by immunotitration experiments with monospecific antibodies directed against pure "young" enzyme; 3) electrophoretic mobilities in polyacrylamide gels, immunological reactivities, and subunit molecular weights; 4) inactivation profiles during controlled thermal denaturation; and 5) kinetics of inactivation by the active-site probe diethyldithiocarbamate. Moreover, levels of cyanide-sensitive SOD activity were found to be very similar in livers of old and young animals. The present work thus indicates that: 1) defective SOD molecules do not accumulate in liver cells of senescent Fischer rats, and 2) the content of catalytically active SOD molecules is not appreciably altered in rat liver cells during aging. (Supported by NIH Grant AG 01002.)

THE EVALUATION OF A HEALTH EDUCATION CAMPAIGN

Marianne Murdock. School of Nursing, Univ. of Ala. in Birmingham, Birmingham, AL 35294. Robert H. McKnight. School of Hygiene and Public Health, The Johns Hopkins Univ., Baltimore, MD 21205.

The research was intended to evaluate the effectiveness of mass media and interpersonal channels in providing the residents of three Southern Illinois communities with information about hypertension. According to the agenda-setting hypothesis, which served as the theoretical basis, receipt of information from both mass media and interpersonal channels considered in combination with individual psychosocial characteristics and interpersonal discussions produce cognitive, affective, and behavioral changes. One hundred and forty-nine residents of three rural Illinois communities were interviewed at three points in time over a one year period to determine if cognitive and affective changes were produced by their having been exposed to a national and local hypertension information campaign. A repeated measures analysis of variance indicated there were statistically significant increases in the respondents' knowledge of the causes of hypertension following exposure to the national and local information campaigns. Interest in, perceived importance and seriousness of hypertension changed statistically over the three measuring periods, with the most significant increases appearing between the baseline and the measuring period following the information campaigns. The high, positive correlations exhibited between reported knowledge about hypertension and the content of media and interpersonal messages about hypertension indicates cognitive and affective health agendas can be suggested by the mass media.

PREDICTION OF SUCCESS ON PROFESSIONAL LICENSURE EXAMINATIONS

Robert H. McKnight. School of Hygiene and Public Health, The Johns Hopkins Univ., Baltimore, MD 21205. Marianne Murdock and William H. Fite. School of Nursing, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The purpose of this research was to predict baccalaureate students' performance on subtests of the state board test pool examination (SBTPE). Data were collected on 81 senior nursing students enrolled in a publicly-supported baccalaureate degree program in the Southeast. A multiple regression analysis indicated high school curriculum content, stress scores, reading scores, and National League for Nursing Achievement Test scores were statistically significant predictors of performance on the five subtests of the professional licensure examination. Use of these data will predict median performance on the professional licensure examination in 75% of the cases. This methodology and these results could be used in establishing a data-based performance index for potential licensees. There are implications for enhancing the cost-effective education of the nursing student given the availability of a model to predict performance on the professional licensure examination.

ESTRADIOL AND PROGESTERONE ACTION ON RAT UTERINE COENZYME LEVELS

Mark A. Donahue, Larry R. Boots, and C. C. Coleman. Dept. of Obstetrics and Gynecology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Uterine weight, folate levels and activities of aspartate aminotransferase (AST), glutathione reductase (GR) and thiamine transketolase (TTK) were determined in 35 ovariectomized rats 16 hrs after the last of 3 daily s.q. injections of steroid in oil. The three treatment doses of steroids were as follows: estradiol (E), 0.1-0.5 μ g; progesterone (P), 1-5 mg; and a combination of 0.25 μ g E and 2.5 mg P. Uteri were homogenized, one horn in cold 0.1M 2-mercaptoethanol, the other in cold PBS, and the 1500 xg supernates assayed for folate levels and enzyme activities, respectively. Uteri treated with E weighed approximately 225 mg, those with E + P 160 mg, and those with P, 100 mg. The capacity of uterine conjugase to liberate folate from polyglutamates was not significantly stimulated by any of the hormone treatments. There were also no significant changes in the degree of saturation of AST, GR or TTK by their respective coenzymes, P₅ALP, FAD or TPP. Enzyme activities per mg of uterus (μ Moles of NADH or NADPH oxidized/min) were higher for TTK with E and P (1.98) than with E + P (1.01), while there were no significant effects on AST and GR activity per mg of uterus. Total uterine activity was always lowest after treatment with P and highest in the E-treated groups for all three enzymes. These results indicate that altered hormone levels, ratios and combinations do affect the enzymes and coenzymes of uterine metabolism. This work was supported by DHEW grant #N01-HD-4-2862.

EXPECTATIONS OF REWARDS AND COSTS FOR EXERCISE

Kathleen C. Brown. School of Nursing, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

To foster health-promoting lifestyles, professionals traditionally encourage individuals to perform health behaviors for health rather than non-health reasons. People may perform a health behavior, such as exercise, for both health and non-health reasons. Individual beliefs or expectations may influence participation in vigorous activity. Therefore, the purpose of this research was to investigate the relationship between performance of exercise and expectations of rewards and costs. The sample was 117 adults employed in industry who volunteered to participate. A questionnaire measuring behavioral, cognitive, situational, and sociodemographic variables was developed and subjected to validity and reliability procedures. Frequencies, bivariate and multiple correlation techniques were used to analyze the data. The only aerobic activity which a large percentage of the sample performed was "brisk walks in good weather." Sedentary subjects held higher expectations than vigorous persons on health rewards and were more likely to expect non-health costs. Vigorous respondents held higher expectations than sedentary subjects on non-health rewards. Voluntary exercise was positively related to participation in childhood sports and negatively associated with perception of susceptibility to heart disease and expectations of "trouble" and interference with free time. Recommendations include encouraging this sample to continue participation in brisk walks. An effort should be made to offer exercise activities at the workplace to minimize personal effort, expense, and time. Research on the expectations of rewards and costs for exercise held by other groups of adults would contribute to further understanding of exercise behavior.

A RESEARCH CYCLE--3'5' ADENOSINE MONOPHOSPHATE (cAMP)

Geraldine M. Emerson. Dept. of Biochemistry, Medical Center, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

In 1957 Rall, Sutherland and Berthet (J. Biol. Chem. 224:463) reported that a substance, later identified as cAMP, was produced in liver, heart and skeletal muscle cells under the influence of epinephrine. As the details were worked out: *extracellular epinephrine* works on the *plasma membrane* to activate the enzyme *adenyl cyclase* which catalyzes the intracellular conversion of *intracellular ATP to cAMP*. This cAMP then through a series of reactions, a cascade mechanism, leads to a glycogen phosphorylase activation. The Nobel Prize in Physiology & Medicine was given to Dr. Sutherland in 1971 because his contribution not only gave insight into glycogenolysis but elucidated a mechanism which would prove to be the mode of action of a large number of other hormones affecting a variety of tissues and organs. In recent papers J. B. Blair et al. (J. Biol. Chem. 254:7579 & 7585 {1979}) reported that hepatocytes of immature juvenile rats (27-35 days old) have the adrenergic β receptor mechanism for activation of adenyl cyclase to produce cAMP, as well as the α receptor mechanism which acts by a mechanism separate from adenyl cyclase. By contrast, young adult male rat (60-120 days of age)

Abstracts

hepatocytes lack the β receptor effect. Yet, epinephrine stimulates glycogenolysis in hepatocytes of both age groups. Thus, we are back to the search for the mechanism of stimulation of glycogenolysis in young adult rat hepatocytes by epinephrine!

IS DEGENERATION OF ADVANCED YEARS SEPARABLE FROM DISEASE?

Geraldine M. Emerson. Dept. of Biochemistry, Medical Center, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The life cycle starts at birth; proceeds through infancy, childhood, adolescence, young adulthood, mature adulthood and old adulthood. Certain diseases are characteristic of various segments of this life cycle. If they are not amenable to cure, then disease arising at an earlier stage persists through later stages of the cycle. In order to understand aging, it is necessary that a distinction be made between those residual conditions that are holdovers of an earlier stage AND conditions which are manifest most characteristically in the old adult years. The question demanding an answer is: Were there no well recognized disease which arose at a prior stage in life, would the primary distinction between the mature adult and the old adult be the SLOWING OF ALL PROCESS, be they psychological, physiological or biochemical in nature? What is normal for the mature adult? for the old adult? If the concentration of a certain substance or a function in all persons in their 70th decade is different from the concentration of the same substance or of that same function in all normal persons in their third decade, must we conclude that a pathological process exists in the old adult? Can degeneration of advanced years be separated from disease?

THE INFLUENCE OF SELF-CONCEPT ON ADOLESCENT BEHAVIOR

B. S. Hutton. School of Nursing, Univ. of Ala. in Birmingham, Birmingham, AL 35294. C. M. Henderson. School of Nursing, Univ. of S. Ala., Mobile, AL 36688.

This study was undertaken to determine if there was a difference in the self-concept of those adolescents who practiced socially acceptable behavior and those who practiced socially unacceptable behavior. The sample consisted of 77 adolescents who attended tenth grade at a high school located in a small rural town in North Alabama. A social behavior scale, developed by the researchers, and the Tennessee Self Concept Scale were utilized for evaluation. These two scales, each a self-administered questionnaire, were given to the subjects to complete in a typical high school testing environment. The total scores on the Social Behavior Scale determined which students were identified as practicing socially acceptable behavior or socially unacceptable behavior. A two-tailed t test revealed there was a statistically significant difference at the $p < .01$ level between the self-concept of those adolescents who reported practicing socially acceptable behavior and those who reported practicing socially unacceptable behavior. Thus, the mean self-concept of adolescents who reported practicing socially unacceptable behavior was

Abstracts

significantly lower than those adolescents who reported practicing socially acceptable behavior.

EFFECTS OF THE ASYMMETRIC TONIC NECK REFLEX AND MUSCLE VIBRATION ON WRIST EXTENSION STRENGTH IN NORMAL ADULTS

Ellen L. Curry and Jo A. Clelland. Div. of Physical Therapy, Univ. of Ala., Birmingham, AL 35233.

The asymmetric tonic neck reflex (ATNR) and high frequency muscle vibration are two means by which the excitability of the motoneuron pools of muscles can be increased or decreased. The effects of the ATNR and high frequency muscle vibration on isometric wrist extension strength were studied in 150 normal right handed adults between the ages of 18 and 40. Subjects were randomly assigned to one of five groups. Data collection from two control groups determined any confounding effects of fatigue, experimental learning, or the weight of the vibrator in contact with the skin surface overlying the wrist extensor muscle bellies. Measurements taken from three experimental groups determined the individual and combined effects of the ATNR and vibration. The ATNR was elicited with active head rotation. A significant increase in strength occurred with active head rotation toward the extending wrist; active head rotation away from the wrist significantly decreased strength. Vibration of the extensor surface of the forearm with the head in neutral rotation toward the extending wrist and vibration of the extensor surface resulted in a greater increase in strength than with either technique individually.

REGULATION OF FREE Ca^{2+} LEVELS BY SUBCELLULAR ORGANELLES

Gerald L. Becker. Dept. of Biochemistry, Univ. of Ala. Med. Center, Birmingham, AL 35294.

Cellular membranes contain Ca^{2+} translocases thought to be responsible for regulation of cytosolic levels of free (ionized) Ca^{2+} ($\{Ca^{2+}\}$). To understand better the dynamics of cytosolic $\{Ca^{2+}\}$ regulation, a calibrated Ca^{2+} -selective electrode was used to monitor the changes in $\{Ca^{2+}\}$ occurring when subcellular fractions of mitochondria and endoplasmic reticulum (microsomes) were suspended in an artificial medium resembling cytosol in ionic composition. In this reconstituted system for intracellular Ca^{2+} transport, liver mitochondria alone regulated $\{Ca^{2+}\}$ toward a constant value of about $0.5 \mu M$, which was restored through uptake or release of mitochondrial Ca^{2+} after $\Delta \{Ca^{2+}\}$ had been produced by addition of Ca^{2+} or chelating agent. Inclusion of liver microsomes in the system resulted in a lower value of steady state $\{Ca^{2+}\}$ (about $0.2 \mu M$), but this additional component of $\{Ca^{2+}\}$ buffering provided by microsomes was exhausted by much smaller increments of added Ca^{2+} than those required to saturate mitochondrial $\{Ca^{2+}\}$ buffering. (Supported in part by grants from the UAB Graduate School.)

THE ROLE OF THE NURSE CONSULTANT IN DEVELOPING A RURAL CLINIC

Frances Lange. Univ. of Ala. School of Nursing, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The concern of this study is rural health and rural health care specifically through the establishment of a health clinic that utilizes the nurse practitioner to provide primary health care services. The central questions posed in this dissertation are: (1) What are the issues relevant to the design and development of a community-run rural nurse practitioner primary health care clinic? (2) Who makes the decisions relevant to the major issues? (3) How is the nurse consultant involved in the decision-making process? (4) How can the nurse consultant effect change at the community level? The questions are responded to in terms of an identification of the common task or tasks to be accomplished with an emphasis on the analysis of actor interactions. The study utilizes both a decision-making model for evaluating community action and a model for evaluating the effectiveness of consultative activities.

A PLASMA SUPEROXIDE-DEPENDENT CHEMOTACTIC FACTOR
FOR HUMAN NEUTROPHILS

William F. Petrone and Joe M. McCord. Dept. of Biochemistry, Univ. of S. Ala., Mobile, AL 36688.

Neutrophils stimulated with various substances (e.g. bacteria, immune complex) generate substantial amounts of the oxygen radical, superoxide, by a membrane bound NADPH oxidase. The superoxide which is liberated into the phagosome plays an important role in destroying phagocytized micro-organisms. A significant amount of superoxide, however, is released into the surrounding (inflammatory) medium where it can interact with serum components. *In vitro*, plasma treated with superoxide becomes potently chemotactic. The generation of this chemotactic activity is inhibited by the radical scavenger, superoxide dismutase, but not by catalase. The superoxide-dependent chemotactic factor does not stimulate superoxide production or degranulation by neutrophils. When superoxide-treated plasma or a superoxide generating system is injected intradermally into rats, there is a heavy infiltration of neutrophils into the injection site. The accumulating cells are not stimulated to produce superoxide or to release granular enzymes and thus are not able to cause overt signs of inflammation. The superoxide-dependent chemotactic factor consists of a chloroform-extractable component bound to serum albumin. This factor plays an important role in communicating and amplifying the neutrophil-mediated inflammatory events. The anti-inflammatory properties of superoxide dismutase appear to be due to its ability to prevent the formation of the superoxide-dependent chemotactic factor. (Supported in part by grants AM 20527 and AM00595 from the U.S. Public Health Service.)

Abstracts

A NOVEL SYNTHESIS OF FOLIC ACID AND AMINOPTERIN

S. R. Adapa and M. G. Nair. Dept. of Biochemistry, Univ. of S. Ala., Mobile, AL 36688.

As part of a program aimed at developing synthetic methods towards the construction of various 6-substituted pterins, we have accomplished the synthesis of pteric acid (1) and its 4-amino analogue (2) using a simple and unambiguous procedure. N-(p-carboethoxy)phenyl glycine (3) was prepared by fusing ethyl p-aminobenzoate with α -bromo acetic acid. After protecting the amino group of 3 as trifluoroacetyl derivative, the corresponding bromomethyl ketone (4) was prepared by using the Arndt Eistert procedure. Treatment of 4 with sodium azide gave the corresponding azidomethyl ketone (5). Protection of the carbonyl group of 5 as dimethyl ketal followed by hydrogenation yielded the corresponding aminomethyl ketal (6), which was used as the key intermediate for the construction of the title compounds. Condensation of 6 with either 2-amino-6-chloro-4-hydroxy-5-nitropyrimidine or 6-chloro-2,4-diamino-5-nitropyrimidine gave the corresponding pyrimidine intermediates, which were elaborated to the corresponding pteric acids by a series of reactions involving deprotection, dithionite reduction, cyclization, thermal aerobic oxidation in DMF and hydrolysis. These procedures were similar to those previously reported from our laboratory for the synthesis of related compounds. Both pteric acid (1) and 4-amino-4-deoxyptericoic acid (2) obtained in this manner were identified with authentic samples in all respects. (Supported by American Cancer Society Grant #CH-53B and NIH Grant #CA 27101.)

UNIVERSITY OF ALABAMA SCHOOL OF NURSING RESEARCH DEVELOPMENT

Kathryn Barchard Daniel and Nita Davidson. Univ. of Ala. School of Nursing, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Research in nursing has evolved historically from nursing and nurses being researched by others such as sociologists and psychologists to beginning nurse researchers viewing characteristics of nurses. The present status of research in nursing involves nurses viewing nursing through 1) case histories of patients, 2) descriptive studies of nursing practice, 3) comparative descriptive studies of nursing interventions, and 4) quasi and experimental research for the improvement of nursing practice. The academic research preparation of nurses is discussed as well as the researcher roles assumed by nurses. The concerted efforts to facilitate research in nursing at UAB are presented as well as examples of research productivity that have emerged.

CALMODULIN LOCALIZATION IN MAMMALIAN SPERMATOZOA

Harold P. Jones. Dept. of Biochemistry, Univ. of S. Ala., Mobile, AL 36688. Barry Palevitz. Dept. of Botany, and Richard W. Lenz and Milton J. Cormier. Dept. of Biochemistry, Univ. of Georgia, Athens, GA 30602.

In light of the recently discovered importance of calmodulin as a regulator of calcium-controlled cellular events and the long recognized importance of calcium in acrosomal activation, studies were undertaken to determine the potential role of calmodulin in the regulation of sperm activation and function. Examination of spermatozoa isolated from a wide range of sources revealed the presence of high levels of calmodulin concentrated primarily within the sperm head. Indirect immunofluorescence studies, undertaken to more precisely determine calmodulin localization within rabbit and guinea pig spermatozoa, revealed calmodulin localized in four distinct areas of the sperm including the anterior one-third of the head, the posterior portion of the equatorial segment, and two distinct regions at the base and tip of the flagellum. This pattern of localization suggests important roles for calmodulin in the processes of acrosomal activation, sperm-egg fusion, and sperm motility. (This work was supported in part by NIH Grant HD-05807-01 to H. P. Jones, National Science Foundation Grants PCM 78-18692 to B. A. Palevitz, and PCM 79-12316 to M. J. Cormier.)

IMPROVED METHODS FOR RECOMBINANT cDNA CONSTRUCTION

Jim W. Gaubatz. Dept. of Biochemistry, Univ. of S. Ala., Mobile, AL 36688. Gary V. Paddock. Dept. of Immunology and Microbiology, Medical Univ. of South Carolina, Charleston, SC 29403.

The untranslated ends of eukaryotic mRNA are important to proper regulation of gene expression. Methods have been developed for sequencing these regions in abundant mRNAs such as globin, but they are not applicable to mRNAs obtained as only minor components. Alternatively, available recombinant cloning methods require S1 nuclease to open the hairpin loop of *in vitro* synthesized double-stranded cDNA. This results in the destruction of terminal sequences, especially in the 5'-end region. We have developed several cloning methods that circumvent the use of S1 nuclease. One method uses a ribosubstitution step after cDNA synthesis. The ribonucleotides become a linker segment that prime the synthesis of a second strand by DNA polymerase. The linker is hydrolyzed by alkali or RNAase to open the hairpin for recombination. A second technique involves extending the 3'-OH of a double-stranded hairpin cDNA with a homopolymer. Both strands of the hairpin molecule may now serve as a template for the Klenow fragment of DNA polymerase I (lacking 5'→3' exonuclease) when a complementary primer is present. The resulting molecules should have a center of symmetry at sequences representing the 5' end of mRNA. We have obtained clones for duck and rabbit globin mRNAs using both methods. Some of the recombinant DNAs fit size classes predicted for the two types of cDNAs. We are currently sequencing these DNAs to determine if the complete 5' regions are included.

THE ACTION OF DIDS ON THE *IN VITRO* GASTRIC MUCOSA

Richard L. Shoemaker. Dept. of Physiology and Biophysics, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

A disulfonic stilbene, DIDS [4,4'-Diisothiocyano-2,2'-Disulfonate], was added to the nutrient solution bathing *Rana pipiens in vitro* gastric mucosa. The pH stat technique was used to estimate the acid secretion rate, and a four electrode system was used to measure transmucosal membrane potential (V_{SN} = secretory calomel electrode in reference to nutrient solution calomel electrode). DIDS at a concentration of $5 \times 10^{-4}M$ produced reversal in the polarity of the potential, V_{SN} = -16 mV for control to +6 mV; along with the voltage change, the H^+ secretion rate decreased from 5 to $2.7 \mu Eq/hr/cm^2$, but there was not significant change in the electrical resistance of the mucosa. In some experiments the short circuit current (I_{SC}) was measured and after the addition of DIDS the polarity reversed and the proton current was always greater than the I_{SC} . DIDS added to the secretory solution produced an average of 5 mv hyperpolarization, i.e. V_{SN} became 5 mv more negative. The effects of DIDS were not reversible. The action of SITS was similar to DIDS but a greater concentration of SITS was required. The reduction in the proton transport rate could be due to the inhibition of the $HCO_3^-Cl^-$ exchange on the nutrient membrane of the oxyntic cells.

PROLACTIN RESPONSE VARIATION DURING INITIATION OF LACTATION

Ellen B. Buckner, Susan Brunssen, and Larry Boots. Univ. of Ala. School of Nursing and Dept. of Obstetrics & Gynecology, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Twenty breastfeeding mothers were followed during the first week postpartum. The prolactin response to suckling (PRS) was measured and milk obtained by baby recorded at a feeding every other day during hospitalization. The PRS was significantly lower on postpartum day 3 or 4 in women experiencing their first pregnancy, compared to women in their second or later pregnancy regardless of how that pregnancy was terminated ($p < .05$). There was no difference in PRS in women compared by first vs. second/later living child, vaginal vs. Cesarean section delivery, delayed vs. early initiation of regular nursing or previous vs. no breastfeeding experience. The PRS was diminished in several cases when the woman was febrile (> 100 degrees F.). Milk obtained by baby showed marked variation in the sample. Values of 0-75 cc per feeding occurred on postpartum day 3-4. Implications for nursing practice include: (1) application of this information in separating physiological and psychological factors predisposing to poor lactation, (2) application of the information in process of formulating nursing diagnoses in the mother experiencing difficulty with breastfeeding, and (3) application to investigation of treatment alternatives for women with poor initiation of lactation. This research was supported by a Faculty Research Grant from the University of Alabama in Birmingham Medical Center.

OBSERVATIONS ON THE BIOSYNTHESIS OF FOLYLPOLYGLUTAMATES

Charles M. Baugh and Ellie Braverman. Dept. of Biochemistry, College of Medicine, Univ. of S. Ala., Mobile, AL 36688.

A large number of folic acid analogs have been synthesized. A few, such as methotrexate, are widely employed as chemotherapeutic agents in treatment of certain cancers. It is now well documented that methotrexate is metabolized *in vivo* like folic acid to higher molecular weight forms containing one, two, or more additional γ -glutamyl residues. This laboratory attempted to establish a bacterial screen in order to study the substrate specificity of the pteroyl-polyglutamate biosynthetic system. A variety of folate analogs would be screened by measuring the incorporation of radioactivity from labeled glutamic acid. Surprisingly, we were unable to demonstrate glutamate incorporation into folic acid *per se*. These results led to a large number of experiments designed to optimize the incorporation of glutamic acid into the folylpolyglutamates. Various labeled glutamates and potential glutamate precursors in a variety of bacterial systems, including a glutamate-requiring mutant of *E. coli*, have now been studied. Our tentative conclusion is that glutamic acid is not the direct precursor of the glutamyl moiety of the folylpolyglutamates.

ULTRASTRUCTURE AND HISTOCHEMISTRY OF DUCTS IN THE ALBUMEN GLAND OF THE APPLE SNAIL, *POMACEA PALUDOSA*

Patricia E. Vermeire. Electron Microscopy Center, College of Medicine, Univ. of S. Ala., Mobile, AL 36688.

The albumen gland of *Pomacea paludosa*, a prosobranch gastropod, contains ducts of the albumen and capsule glands. The capsule gland duct coils through the anterior portion of the albumen gland and is composed of two opposing faces, each of which has two layers. The upper layer contains ciliated cells and the goblet-shaped processes of secretory cells. Bodies of secretory cells comprise the lower layer. Secretory cells of the anterior surface secrete non-sulfated acid mucopolysaccharides of medium electron density. They contain lobulated nuclei, many Golgi complexes, and little rough endoplasmic reticulum. In contrast, secretory cells of the posterior face produce a protein-rich secretion and contain granules with eccentric, electron dense subunits. They also contain lobulated, basal nuclei, numerous Golgi membranes, and few cisternae of rough endoplasmic reticulum. Surfaces of the duct are covered by cilia with microvilli interspersed between the cilia. The histochemistry and ultrastructure of both types of secretory cells resemble but are not identical to goblet cells of the vertebrate intestine. Secretions arising from both faces of the capsule gland duct contribute to the complex layers surrounding the fertilized egg and may facilitate the movement of the eggs through the albumen gland by the ciliated cells.

THE BIOCHEMICAL TRANSFER, VIA WHOLE BRAIN HOMOGENATE,
OF AN ACQUIRED OPERANT TASK IN THE RAT

Philip E. Morris and John M. Beaton. Birmingham Southern College and Neurosciences Program, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

It has been shown that the administration of trained donor brain extract to naive rats results in facilitation, or more rapid acquisition, of a task. In the present study a group of food deprived rats were trained to press a lever in a Skinner box on a schedule of continuous food reinforcement until they reached the criterion of at least 100 bar presses per 30 minute session on five consecutive days. At this point in time the animals were sacrificed, the brains excised and processed as follows. The brains were homogenized in deionized water and the homogenate dialyzed against 12 ml of deionized water for every ml of homogenate for 20 hours. (A dialyzing membrane with a cut-off of 3,500 a.m.u. was used.) A group of untrained food deprived rats were also sacrificed and their brains treated similarly. The dialyzates from both groups were lyophilized and the resulting powders were resuspended in a volume of water to allow the injection of the equivalent of two donor brains per recipient rat to the experimental (trained donor) and control (untrained donor) groups. A second control group was run which received saline injections. All injections were administered intraperitoneally. Each group had 10 rats. The animals were tested individually for one hour sessions at 18, 42 and 66 hours after injection. The number of bar presses made by each rat was noted and the mean plus or minus the standard deviation were calculated for each session. The results of a one-way analysis of variance showed that the group which received trained donor brain extract performed significantly better than either control group. These data suggest that some factor associated with the task had been transferred in these rats.

AUDIO BIOFEEDBACK AND LEVEL OF STRESS DURING LABOR

Sylvia Squires Britt. Univ. of Ala. School of Nursing, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

The purpose of the research is to determine the effectiveness of the nursing intervention of continuous audio biofeedback as a means of assisting minimally prepared primigravidas to adapt to labor. Selye's framework of stress/adaptation provides theoretical guidance for the study. An experimental design will be followed with a total sample size of approximately 40 women. Criterion measures selected for the study include the physiologic parameters of muscle stress, pulse rate, respiratory rate and systolic and diastolic blood pressure. All parameters except muscle stress are usually monitored during labor. Potential participants will be identified during early labor shortly after admission to the hospital. Informed consent will be obtained prior to participation in the study. The control group will be monitored for criterion measures every fifteen minutes throughout labor by the researcher. Experimental participants will be introduced to audio biofeedback during a twenty minute session in early labor. These women will also be monitored for criterion measures every fifteen minutes throughout labor. Biofeedback will be accomplished using the J33 Cyborg unit which clicks to

indicate the degree of muscle stress. Disks will be attached to the fontalis muscle of the laboring woman. Research has shown that the fontalis muscle provides an indication of the degree of tension in the body. Once all data is collected regression analysis will be used to examine several null hypotheses. Criterion measures will be transformed to non-normalized standard (Z) scores and summed for comparison as summary stress scores.

HISTAMINE: SOURCE AND FUNCTION IN NUCLEUS ACCUMBENS

R. B. Chronister. Dept. of Anatomy, Univ. of S. Ala., Mobile, AL 36688.
J. F. DeFrance. Dept. Neurobiol. Anatomy, Univ. of Texas Health Sci. Center, Houston, TX 77025.

Histamine is now regarded as a neurotransmitter. It is implicated in schizophrenia and in the binding of tricyclic antidepressants. Bidirectional transport of horseradish peroxidase was used to ascertain the source of histamine. To elucidate mechanisms, the effect of 4-Me-histamine (H_2 moiety) was determined on evoked field potentials. In both the anatomical and physiological studies, the area investigated was nucleus accumbens of the rabbit, an area also implicated in schizophrenia. The anatomic studies suggest that histamine arises from the nuclei adjacent to the mamillary region; specifically, the nuclei gemini and the nuclei of the mamillary peduncle. Microstimulating electrodes (1-5 meg ohm) were placed on the fimbria hippocampi and (10-30 μ a) wave pulses used to drive neurons in nucleus accumbens. Multibarrel pipette arrays were positioned in accumbens for recording (5 meg ohm), iontophoresis (10-40 na), and current balancing. Histamine exhibited a complex inhibitory effect on the field profiles. At 0.5 Hz stimulation, histamine showed a slight inhibition. At 6 Hz stimulation, histamine showed a marked inhibitory effect. These effects are reversed by metiamide, an H_2 blocker. The histamine effect was mediated by GABA. Dopamine had the opposite effect; maximum inhibition at 0.5 Hz with only a little evident at 6 Hz. Thus, histamine and dopamine have complimentary effects in nucleus accumbens. This interaction adds new insight to aromatic amine function in the CNS and to possible mechanisms underlying abnormal mental states. (Supported by 1-R03-MH-32418, 1-R01-MH 31114, and the Scottish Rite Schizophrenia Foundation.)

SCANNING ELECTRON MICROSCOPY IN DERMATOPATHOLOGY

Walter H. Wilborn. Dept. of Anatomy and Electron Microscopy Center, College of Medicine, Univ. of S. Ala., Mobile, AL 36688.

Scanning electron microscopy (SEM) was used to study the surface anatomy of normal skin, sweat glands, and some common cutaneous lesions (e.g., comedones of acne, psoriasis, seborrheic keratoses, keratoacanthomas, nevi, dermatofibromas, fungal infections, etc.). Most specimens were prepared by the conventional method of double fixation (glutaraldehyde and osmium tetroxide) and critical point drying. A significant finding was that specimens fixed in 10% neutral buffered formalin and

embedded in paraffin were shown to be adequate for SEM. The results of this study provided new information relevant to cutaneous physiology and the histogenesis of cutaneous lesions. Secretory cells of apocrine sweat glands released their secretory products by apocrine and microapocrine methods. Products for exocytosis first became evident as apical, cellular protrusions which bulged into the lumina. In acne, the comedones contained scales, hairs, sebum, bacteria, and yeasts. Seborrhic keratoses and keratoacanthomas were characterized by keratin plugs or cysts formed by whorls of scales which arose from hair follicles. Psoriatic lesions manifested abnormal scales with holes, elongated rete pegs, and defects in the basement membrane. Most cutaneous lesions contained more microorganisms than areas of uninvolved skin adjacent to the lesions. Some lesions were encrusted with lymphocytes. In *Candida albicans* infections, the fungi were both extracellular and intracellular. Nevus cells had ruffled surfaces and occupied cell nests. The findings clearly showed that surface topographical patterns provided by SEM are of immense value in gaining a better understanding of cutaneous biology.

A NURSING CLINIC--ALTERNATIVE FOR HEALTH CARE OF THE AGED

Mildred L. Hamner. School of Nursing, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Health care for the aged is one of the most sought after commodities, yet it is often inaccessible. Numerous aged persons have inadequate care because of diminished finances, lack of transportation, inadequate resources and/or knowledge deficit about the need for health promotion practices. A solution which could greatly enhance the health care of the aged is a greater utilization of nurses prepared to implement primary care to the aged citizens before catastrophic illnesses occur. A clinic such as this was initiated at a local apartment complex for those persons who are over 62 years of age and/or disabled. At present there are 214 active clients. Services include health screening activities, health teaching, referrals, administration of medicines as recommended by their personal physician, with a large amount of ego support as a valuable by-product. The benefits are obvious in that the residents are more secure about their health care, while referrals have upgraded their level of wellness. Nursing students who have their clinical experience at a clinic of this nature derive benefit from relating to the healthy aged person and hopefully may choose to become involved with the health care of the aged. Herein lies the key to future successes.

IMPLICATIONS OF TRYPTAMINE IN HYPERTENSION

Robert Harrison. Neurosciences Program, Dept. of Physiology/Biophysics, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

It has been suggested that peripheral resistance in animal models of genetic and induced hypertension involves hypertrophic structural changes in precapillary arteriolar beds (Folkow, 1978). These changes may be due to presence of a potent (<100 µg/kg I.P.) vasopressive agent, tryptamine,

since conditions which induce chronic elevation in systolic BP values (Gardiner and Bennett, 1977; Rosecrans et al., 1977; and others) also produce increases in tryptophan decarboxylation product concentrations in rat brain and adrenal glands (Harrison and Christian, 1979 and others). Tryptamine and other indolealkylamines were assayed via isotope dilution GC/MS. The greatest changes of indolealkylamine content were noted in adrenal glands taken from young (60 day old) rats that were short term (=10 days) individually housed. Tryptamine was found to increase linearly with respect to time in individually housed animals over the period studied, whereas brain tryptamine did not appear to significantly increase after 30 days of individual housing. There is substantial agreement between the pharmacology and order of appearance of tryptamine and its metabolites and physiological effects accompanying experimental production of hypertension. It is concluded that further investigation into the role of tryptamine and its metabolites in hypertension etiology may prove clinically efficacious.

ENGINEERING

RESEARCH, DEVELOPMENT AND ACQUISITION INVESTMENT STRATEGY

Harold L. Pastrick. Guidance and Control Directorate, U.S. Army Missile Laboratory, Redstone Arsenal, AL 35809.

An analysis is made of the Office of the Secretary of Defense's Land Warfare program for the present fiscal year, 1980. To place the program into perspective on an international scale, the threat projections in five potential theaters of confrontation are examined. Surge and readiness requirements then direct attention to the investment strategy that includes the total federal program and budget available as fundamental resources. Included for consideration is the Army's bow-wave effect on future procurements and its impact on weapon system acquisition. Opportunities for new initiatives in the area of helicopter armament, new tank concepts, mine and barrier concepts and combat vehicles are investigated. The resultant strategy is examined in terms of rationalization, standardization and inter-operability with NATO-derived systems, force multipliers, increased systems survivability and decreased acquisition costs for proliferation gains.

FROM RESEARCH TO DESIGN IN STEEL BOLTED CONNECTIONS

N. Krishnamurthy. Dept. of Civil Engineering, Univ. of Ala. in Birmingham, Birmingham, AL 35294.

Bolted connections are among the most important, complicated, labor-intensive--and hence expensive--elements in steel structures. Traditionally their design has been overly conservative, based on classical mechanics solutions of simplified models. With the increase in their use in recent years, coupled with increasing material and labor costs, a review of the state-of-the-art and additional research towards

increased understanding and the development of improved design procedures have been found necessary. The paper presents the case history of the author's involvement in the research and the design development of one particular type of steel bolted connection, namely the "end-plate connection," consisting of a plate welded to the end of an 'I' beam and attached to the column flange or other support by pretensioned bolts at the beam flanges. The industry was polled on the dimensions and other details of end-plate connections in common use. Finite element models of the typical connection were developed, and feasibility, convergence, sensitivity, and parameter studies were conducted, generating data on their behavior all the way from bolt pretensioning to connection or beam failure. Multiple regression analysis was employed to determine governing equations from the data. Steel prototype and photoelastic model tests were conducted, first to validate or refine the models, and later to check the conclusions from the analyses. A new design procedure has been proposed, and generally accepted by the industry, which results in considerable savings. The research was sponsored by the American Institute of Steel Construction and the Metal Building Manufacturers Association.

ACTIVE CONTROL OF FLEXIBLE STRUCTURES

S. M. Seltzer. Control Dynamics Co., Huntsville, AL 35802.

Over the past several years considerable attention has been directed toward predicting and controlling the dynamic behavior of large flexible spacecraft in Earth orbit. Within this complex area the spacecraft usually is required to meet stringent pointing and stability requirements. Sometimes the shape of the craft, or a portion thereof, must also be controlled. This must be performed under the influence of both on-board and external disturbances. The problem is aggravated severely by the high degree of flexibility brought about primarily by limitations on structural mass that can be placed into orbit. The result is numerous, densely packed, low frequency vibrational modes. The problem of actively controlling the attitude and structure of such large orbiting space systems is being attacked under direction of the Department of Defense Advanced Research Projects Agency and the National Aeronautics and Space Administration. The control problem posed consists of pointing and controlling the attitude and shape of a flexible spacecraft. The dynamic modeling problem is described, as are several current control philosophies. The most serious problems that have been identified during the course of these programs are set forth. (Partially supported by contract with The Charles Stark Draper Laboratory, Inc.)

A TIME-TO-GO ALGORITHM USING ACCELERATION INFORMATION

Randy J. York. Dept. of Mathematics and Computer Science, Western Kentucky Univ., Bowling Green, KY 42101.

This work employs acceleration information in updating the estimate of time-to-go, tgo, a quantity of prime interest when the tactical missile

is being guided by an optimal control law. A stored, prelaunch profile of missile centerline acceleration is used along with range, range-rate information in predicting tgo every t seconds. Actual inflight acceleration measurements are incorporated as well when they are available in order to examine their effect. Graphs show that more accurate estimates of tgo are obtained, and the corresponding improvements in performance are given in tabular form. Currently, target acceleration is being factored into the algorithm. Care has been taken to use a realistic 6 DOF simulation in trying to verify the effectiveness of the new algorithm. Preliminary results indicate improvement in performance for missile-target scenarios of previously marginal lethality. Monte Carlo sets will be run in the future to confirm the initial conclusions and to examine possible sensitivity problems that might be present. This work has been supported by the U.S. Army Research Office.)

THE USE OF CONTINUOUS SYSTEM SIMULATION LANGUAGES
IN REALTIME MISSILE SIMULATIONS

Alexander C. Jolly. U.S. Army Missile Command, Redstone Arsenal, AL 35809.

The increasing use of computer simulation as a tool in the fields of systems analysis, research and engineering has led to the development and implementation of specialized computer simulation languages. The objectives of such language designs are to promote speedy development of simulations and to make the computer easily accessible to non-specialist computer users. This paper surveys the background which has led to the development of various simulation languages and then describes the extensions to a particular language which are necessary to permit real-time simulations (in the sense that a unit of realtime corresponds exactly to a unit of simulated time) to be programmed in that language. An example of a simulated air-to-surface missile, linked to a real piece of guidance hardware, is used to illustrate the technique.

SINGULARITY EXPANSION METHOD ANALYSIS OF TWO FINITE
LENGTH THIN CYLINDERS OF ARBITRARY ORIENTATION

D. Maynard Schmale and Lloyd S. Riggs. Dept. of Electrical Engineering, Auburn Univ., Auburn, AL 36830.

The scattering characteristics of two variable length arbitrarily oriented, perfectly conducting, right circular cylinders are investigated. Pocklington type integrodifferential equations with thin wire kernels are formulated in terms of a complex frequency variable for the currents induced on the scatterers. The system equations are reduced to matrix form by application of the Method of Moments. Results will be case in terms of the Singularity Expansion Method. Specifically, trajectories of the natural resonances of the scattering system will be presented. Comparison of work done by previous investigators (Shumpert, T. H., K. R. Umashankar, and D. R. Wilson, IEEE Trans. Ant. Prop., 23, 2, 1974), will afford some interesting results with respect to the fundamental scattering characteristics of cylinders.

ON IMPLEMENTING THE SIGN/LOGARITHMIC FAST FOURIER TRANSFORM

D. V. Satish Chandra and Scott A. Starks. Dept. of Electrical Engineering, Auburn Univ., Auburn, AL 36830.

With the rapid advances in large and very large scale integration, a growing number of complex digital signal processing applications such as digital filtering and discrete Fourier transform computations are becoming economically feasible. In the last decade, many number systems have been proposed and used to implement arithmetic units of signal processors. The familiar two's complement number system using either fixed or floating point arithmetic suffers from the lack of simple multiplication algorithms. Residue arithmetic is generally unsatisfactory for signal processing due to the lack of simple scaling and rounding algorithms. This paper describes the use of sign/logarithmic number system for spectral analysis using the fast Fourier transform (FFT). Algorithms for sign/logarithmic addition, subtraction and multiplication are briefly reviewed. A theoretical analysis of the noise-to-signal ratio in the sign/logarithmic FFT is presented. The theoretical results are verified in computer simulation experiments for different input sequences. The experimental results indicate that the sign/logarithmic number system gives a superior performance to that of a floating-point system of equivalent word length and dynamic range, with an added advantage of the ease of implementation of arithmetic algorithms in the sign/logarithmic system.

AN OPTIMAL LINEAR MAP FOR PATTERN RECOGNITION

Mark D. Vanstrum, S. E. Phokachaipatana, and Scott A. Starks. Dept. of Electrical Engineering, Auburn Univ., Auburn, AL 36830.

This paper presents a new approach to linear feature extraction which has been found to be very effective in the analysis of multivariate data. For a given set of training data of high dimensionality, the algorithm generates the optimal linear map for transforming the data to a space of lower dimensionality. The criteria for optimality of chosen to be a functional based upon the preservation of interpoint distances under the transformation. This choice of the optimality criteria makes this algorithm ideally suited for cluster analysis. Results from the application of this algorithm to standard data sets are presented.

RADAR TARGET MODELLING TECHNIQUES

Richard J. Machuzak and Edward R. Graf. Dept. of Electrical Engineering, Auburn Univ., Auburn, AL 36830.

An overview of radar target modelling techniques is presented. Target cross section is defined and exemplified by two means: 1) collections of point scatterers and 2) collections of simple geometric shapes. Clearly, neither can perfectly model a real world practical target, for example an army tank or a jet fighter. However, radar simulation studies require as reliable target models as possible. Confidence levels for the model mentioned are discussed.

MINUTES

ALABAMA ACADEMY OF SCIENCE ANNUAL BUSINESS MEETING

Samford University
Birmingham, Alabama

March 22, 1980

The meeting was called to order by President Jack Moore at 8:40 a.m. The President complimented the section officers, members, and local arrangements committee for making the 57th annual meeting a success.

The President reminded all individuals in attendance of the Energy Symposium to be held following the business meeting and thanked Dr. William Mason of Auburn University for his efforts in organizing the symposium. The program participants, their affiliation and topic are:

Dr. Chester C. Carroll--Vice-President for Research--Auburn University, Moderator.

Dr. John Goodling--Associate Professor of Mechanical Engineering, Auburn University: SOLAR ENERGY, CAN WE USE IT NOW?

Dr. Irving Wender--Director of the Office of Advanced Research and Technology: THE ROLE OF COAL IN OUR ENERGY FUTURE.

Dr. Raymond Askew--Professor of Physics, Auburn University: NUCLEAR FISSION, RISK vs. NEED.

Dr. Klaus Steinbeck--Associate Professor of Forest Resources, University of Georgia: BIOLOGICAL ENERGY SOURCES.

Dr. Edward Passerini--Professor of Humanities and Environment, University of Alabama: ENERGY CONSERVATION, A MATTER OF NEED vs. DEMAND.

Dr. Donald Street--Associate Professor of Economics, Auburn University: ENERGY AND ECONOMICS.

Dr. Earl Bailey--Professor of Aerospace and Mechanical Engineering, University of Alabama: STRIP MINING, ENERGY vs. ENVIRONMENT.

The President then called for the Report of the Counselor to the Alabama Junior Academy of Science, Dr. James Welker. No report was submitted.

The President asked for the Report of the State Coordinator of Science Fairs, Mrs. Rosemary Crawford. No report was submitted.

The President then asked for the Report of the Local Coordinator of the Gorgas Foundation, Dr. Levin Hazlegrove.

Minutes

Dr. Hazlegrove announced the rankings of the finalists in the 1980 Alabama Science Talent Search held at Samford University in conjunction with the Alabama Academy of Science annual meeting.

The winner of the cash award of \$1,600 tuition grant was Gerald Garris McGlamery, Jr., 214 Robin Hood Drive, Florence, AL 35630, from H. A. Bradshaw High School; Teacher: Mary Nell Gonce.

Alternates are:

- 1st Michael Lee Brummitt, 106 Kingswood Drive, Florence, AL 35630, from H. A. Bradshaw High School; Teacher: Mary Nell Gonce.
- 2nd Lee Enrico Eslava, Route 2, Box 251, Foley, AL 36535, from Foley High School; Teacher: Mary Amy Sheldon.
- 3rd William Blair Murray, 9833 Red Mill Road, Birmingham, AL 35215, from Huffman High School; Teacher: Robert Sol Davis.
- 4th Daniel Madison Davis, 1001 Olive Street, Florence, AL 35630, from H. A. Bradshaw High School; Teacher: Mary Nell Gonce.
- 5th Michael George Allen, 2319 McBurney Drive, Florence, AL 35630, from H. A. Bradshaw High School; Teacher: Mary Nell Gonce.
- 6th Leigh Ann Horton, 2202 Wellington Street, Florence, AL 35630, from H. A. Bradshaw High School; Teacher: Mary Nell Gonce.
- 7th James Matthew Sullivan, 106 Patsy Drive, Florence, AL 35630, from H. A. Bradshaw High School; Teacher: Mary Nell Gonce.
- 8th Jackie Louise Garner, 2435 Vale Drive, Birmingham, AL 35244, from Briarwood Christian High School; Teacher: Pauline King Long.
- 9th Gary Eugene McGahan, 1925 Woodmeade Street, Decatur, AL 35601, from Austin High School; Teacher: Mrs. Judi Thorp.
- 10th Brett Allen Ayers, 141 Hughes Street, Florence, AL 35630, from H. A. Bradshaw High School; Teacher: Mary Nell Gonce.
- 11th Mary Jo Kurczi, 1109 North Jefferson Street, Athens, AL 35611, from Athens High School; Teacher: Guy McClure.

The rankings were established by a panel of judges consisting of department heads, deans, and professors from many of the leading Universities and Industries in Alabama.

Dr. Levin S. Hazlegrove, Professor and Chairman, Department of Chemistry, Samford University, is Chairman of the Judges Committee.

Winners and alternates in the Gorgas Contests receive offers of tuition scholarships to colleges and universities in Alabama for the study of science. The Gorgas Foundation is named for General William Crawford

Minutes

Gorgas, the Alabama physician who conquered yellow fever in the Panama Canal Zone while serving as Surgeon General in the U.S. Army. The purposes of the Foundation are to promote interest in science and to aid in the education of promising students.

President Moore called for the Report of the Secretary of the Academy, Dr. John Pritchett.

Change in membership during the year was reported and is summarized below:

Total Membership as of April 25, 1979	613
New Members--April, 1979 to present	144
Members Removed From Roll:	
a) Deceased	3
b) Resigned	1
c) Non-payment of Dues	65
Total Membership as of March 17, 1980	688
Net Change	+75

A breakdown of changes in membership by section of the Academy was presented and is summarized in the following table:

SUMMARY OF MEMBERSHIP BY SECTION

	Section													Total
	1	2	3	4	5	6	7	8	9	10	11	88	99	
April 25, 1979	124	42	33	7	44	34	34	27	78	36	17	92	45	613
Adds	49	10	7	6	6	9	2	12	37	7	0	3	0	144
Drops	13	3	9	1	2	4	3	5	14	5	6	1	7	69
March 17, 1980	160	49	31	12	48	39	33	34	101	38	11	94	38	688
Net Change	+36	+7	-2	+5	+4	+5	-1	+7	+23	+2	-6	+2	-7	+75
% Change	+29	+16	-6	+71	+9	+14	-3	+26	+29	-5	-35	-2	-15	+12

President Moore then called for the Report of the Place of Meeting Committee, Dr. Ellen McLaughlin, Chairman.

The Spring 1981 meetings of the Alabama Academy of Science will be held at Auburn University. An invitation was extended by President Philpott and accepted by the Academy.

The 1982 meetings of the Academy will be held at the University of Alabama in Birmingham. An invitation was extended by President Hill and accepted by the Academy.

Minutes

I would like to thank Dr. Urban Diener of Auburn and Dr. Sam Barker of UAB for arranging these invitations. Dr. Bill Alford of Auburn University will be chairman of this committee in 1981.

The President then asked for the Report of the Resolutions Committee, Hoyt Kaylor, Chairman. The following resolutions were presented:

WHEREAS the Alabama Academy of Science has held its 1980 Annual meeting at Samford University, and has enjoyed the hospitality of the University, now therefore

BE IT RESOLVED that the Academy express its gratitude to Dr. Leslie Wright, President, to Dr. Ruric Wheeler, Vice-President for Academic Affairs, and to the University for hosting this meeting, to Dr. Ben Chastain, Chairman of our local hosts, and to the members of his host committee, Dr. Tom Denton, Mrs. Sarah Glass, Dr. Henry Glotfelty, Dr. James Haggard, and Dr. Ellen McLaughlin; to the Faculty and Staff of the University; and to all the many others who contributed to the success of this meeting, we, the Academy members, express our appreciation for their efforts on our behalf.

BE IT FURTHER RESOLVED that the Academy express its appreciation to Dr. Edward C. Tocus for his presentation to the joint Academies, to Dr. William Mason, who organized the symposium, and to Dr. Chester C. Carroll and the members of his panel for the excellent symposium on "Energy and Alabama."

BE IT FURTHER RESOLVED THAT THE Academy express its appreciation to those who retire from leadership in the Academy this year, and especially to Dr. Jack H. Moore, our retiring President.

WHEREAS Dr. Harry Philpott is retiring from the presidency of Auburn University, and

WHEREAS Dr. Philpott has served as a member of the Board of Trustees of the Academy and

WHEREAS his administration has assisted financially in the publication of The Journal of the Alabama Academy of Science, now therefore

BE IT RESOLVED that the Academy express its appreciation to Dr. Philpott for both the personal and the financial support that he has given to the Academy during his tenure of office.

WHEREAS the Academy has received notice of the death of Miss Winifred McGlamery, former staff member of the State Geological Survey, and

WHEREAS Miss Winnie was a long-time member of the Academy, contributing many papers to the Geology Section of the Academy, now therefore

BE IT RESOLVED that the Academy extend its sympathy to the relatives of Miss McGlamery.

Minutes

WHEREAS death has deprived the Academy of the membership of B. W. Gandrud of the Industry and Economics Section, now therefore

BE IT RESOLVED that the Academy extend its sympathy to the family of Mr. Gandrud.

BE IT FURTHER RESOLVED that appropriate letters together with copies of this resolution be sent by the Secretary to the families of both Miss McGlamery and Mr. Gandrud.

President Moore than asked for the Report of the Research Committee, Dr. Al Belmonte, Chairman.

Dr. Belmonte Submitted the following:

The Research Committee is responsible for administering three programs consistent with The Bylaws of the Academy: Student Travel Awards, Student Research Grants, and Student Research Awards.

The Research Committee had 11 Travel Award requests for student travel to the annual meeting. These requests totaled \$967. The committee has awarded \$249 of the budgeted \$250 for this activity and each student will receive some support for their attendance at the meeting. A list of students and amounts awarded has been forwarded to the Treasurer.

The Research Committee had six Student Research Grant requests of which only four could be funded at the \$200 amount. The following grants are approved:

1. Duane D. Chase--Evaluation of the Uranium Potential in the Lower Tertiary of Southern Alabama--Univ. of Ala.--Tuscaloosa.
2. Oliver J. Booker III--Ultrastructure of Myxobolatus in the Largemouth Bass--Auburn Univ.
3. Jayma A. Moore--Investigations on Resistance to Infection with *E. tuskegeensis* in the Cotton Rat--Auburn Univ.
4. William S. Pendexter--Structure and Stratigraphy of the Marble Valley Aroa, Coosa and Talladega Counties--Univ. of Ala.--Tuscaloosa.

The Research Committee had six final papers entered in the Student Research Awards competition: three in Biological Science, two in Social Science, and one in Health Science. The award includes a prize of \$50 and a certificate. Winners are:

1. In Social Science--Henry F. Inman--Persistence of Farm Households: Alabama, 1850 to 1860--Univ. of Ala--Birmingham.
2. In Health Science--Philip E. Morris--The Biochemical Transfer of an Acquired Operant Task in the Rat--Univ. of Ala.--Birmingham.

Minutes

3. In Biological Sciences--Roger J. McPherson--Seasonal Spermatogenesis of *S. odoratus* in North Alabama--Univ. of Ala.--Birmingham.

The President then asked for approval of all reports submitted. A motion was made, seconded, and carried.

President Moore thanked the committees for their efforts on behalf of the Academy. He then asked for the report of the Nominating Committee. Dr. James Wilkes presented the following nominations:

President--Gerladine Emerson
First Vice President--Kenneth Ottis
Second Vice President--Charles Baugh
Journal Editor--William Mason
Counselor to AJAS--James Welker
Board of Trustees--James Sulzby
 Wilbur Devall
 Rosemary Crawford
 N. F. Anderton
State Coordinator, Science Fairs--Elsie Spencer
Section Vice Chairmen
 IV--Forestry--Steven R. Sax
 V--Physics and Mathematics--Stanley Jones
 VI--Industry and Economics--William Stewart
 VII--Science Education--Ernest Riggsby
 VIII--Social Science--Hines Hall

President Moore then called for additional nominations from the floor. There being none, a motion was made that the above slate of officers be elected by unanimous consent. The motion was seconded and passed.

President Moore then asked for items of new or old business.

Dr. Arendale proposed that the incoming President of the Academy appoint a committee to study and recommend possible action concerning inequities in certain areas of teacher certification. After discussion, a motion was made and seconded that such a committee be appointed. The motion passed.

Additionally, in an attempt to gather more complete historical information on the Academy, it was moved and seconded that Mr. James Sulzby correspond with former Presidents of the Academy and ask that they forward their papers to the Academy Archivist. The motion passed.

There being no further business, the meeting was adjourned by President Moore at 9:30 a.m.

GEL ELECTROPHORESIS OF SONICATED VIRIONS OF
TWO NUCLEAR POLYHEDROSIS VIRUSES¹

Shiva P. Singh

Department of Biology
Alabama State University
Montgomery, AL 36195

Robert T. Gudauskas and James D. Harper
Department of Botany, Plant Pathology and Microbiology
and Department of Zoology-Entomology
Auburn University Agricultural Experiment Station
Auburn, AL 36830

Abstract. Virions from two nuclear polyhedrosis viruses were subjected to ultrasonication and analyzed by sodium dodecyl sulfate-polyacrylamide gel electrophoresis. The viruses were *Pseudoplusia includens* singly embedded virion type (SEV) and *Trichoplusia ni* SEV, which infect the soybean looper, *P. includens* Walker, and the cabbage looper, *T. ni* Hübner, respectively. Electrophoresis of virions pooled from samples sonicated for various lengths of time showed 14-15 polypeptide bands ranging in molecular weight (MW) from 11,600 to 87,100. The major polypeptides had MW of ca. 32,500, 36,500, and 52,000, and were common to both viruses. Differences between polypeptide profiles of virions of the two viruses were confined to minor bands or to varying intensity of certain bands.

INTRODUCTION

The nuclear polyhedrosis viruses (Baculoviridae) are one of several types of viruses that infect insects. Characteristically, virions of the nuclear polyhedrosis viruses (NPV) are enclosed singly (SEV) or in multiple numbers (MEV) by an envelope and embedded within a protein polyhedral inclusion body (PIB). The lethality of NPV to larvae of many lepidopterous insect pests has prompted considerable interest in the viruses as biocontrol agents (17). Adequate identification of the NPV is requisite for rational use of them as insecticides and various biological, biochemical, and serologic techniques have been used to characterize the NPV.

Electrophoresis in polyacrylamide gels in the presence of sodium dodecyl sulfate (SDS-PAGE) is a useful tool for the separation and molecular weight estimation of proteins and their subunits (15, 20). The technique has been applied to study proteins of PIB and virions of some NPV (1, 2, 3, 4, 5, 7, 9, 10, 11, 12, 14, 18, 19, 21).

¹Manuscript received 11 December 1979; accepted 15 April 1980.

In an earlier study (16), we subjected virions of four NPV to ultrasonic treatment in an attempt to expose antigenic determinants which otherwise might be obscured by the double membrane system of baculoviruses. The objective of the study reported here was to determine if two NPV, *Pseudoplusia includens* SEV and *Trichoplusia ni* SEV (which infect the soybean looper, *P. includens* Walker, and the cabbage looper, *T. ni* Hübner, respectively), could be distinguished by SDS-PAGE of virion proteins following ultrasonic treatment of the virions.

MATERIALS AND METHODS

The sources of the isolates of *P. includens* SEV and *T. ni* SEV, and the procedures for purification of PIB and solubilization of them to release virions were described previously (16).

Virions, equivalent to 5 mg protein (8), were suspended in 10 ml of 0.01 M Tris buffer, pH 7.4, in 3.2 × 8.9 cm cellulose nitrate tubes. Tubes were submerged in crushed ice to a level well above tube contents. The probe tip of a sonicator (Biosonic III; Brownhill Scientific, Rochester, NY) was set just beneath the meniscus and driven at maximum output (105 W/cm²) for 5-min intervals. Sonicates were centrifuged at 125,000 g for 1 hr at 4 C. To obtain morphologically comparable components of the viruses, pellets from ultrasonic treatments of 5, 10, and 20 min of *P. includens* SEV were pooled, as were those for 10, 20, and 30 min of *T. ni* SEV. The pellets were resuspended in Tris buffer, and stored at -12 C until used in SDS-PAGE analysis.

The method of Shapiro et al. (15) was used for separation and molecular weight estimation of polypeptides from sonicated virions. Separations were performed on 7.5% polyacrylamide gels (acrylamide; N, N'-methylene bisacrylamide; 0.1% SDS; 0.1 M Na₂HPO₄, pH 7.2) measuring 70 × 5 mm. The electrode buffer was also 0.1 M Na₂HPO₄, 0.1% SDS, pH 7.2. Virion samples were mixed with 0.01 M Na₂HPO₄ buffer, pH 7.2, containing 1% SDS, 1% β-mercaptoethanol, 10% glycerol and 0.002% bromophenol blue, and heated at 100 C for 5 min. Aliquots of virion preparations (25 μg protein) were layered onto each gel and subjected to electrophoresis at 5 ma/gel until the tracking dye reached the bottom of the gel. Following electrophoresis, gels were fixed in 10% (w/w) trichloroacetic acid and stained overnight with 0.02% Coomassie brilliant blue in methanol, acetic acid, and water (5:1:5) and destained in methanol, acetic acid and water (5:7.5:87.5) for 48-72 hr.

Molecular weights (MW) were estimated by comparison of relative migration of virion protein bands with those of known marker proteins (Fig. 1): phosphorylase a (MW 93,000), catalase (57,000), ovalbumin (45,000), aldolase (39,500), pepsin (35,000), trypsin (24,000) and lysozyme (14,300) (Sigma Chemical Co.).

RESULTS AND DISCUSSION

A total of 14 and 15 bands was separated and reproducibly detected for *P. includens* SEV and *T. ni* SEV, respectively (Fig. 2); the top band (band 1) was too faint to be photographed. Molecular weights of the

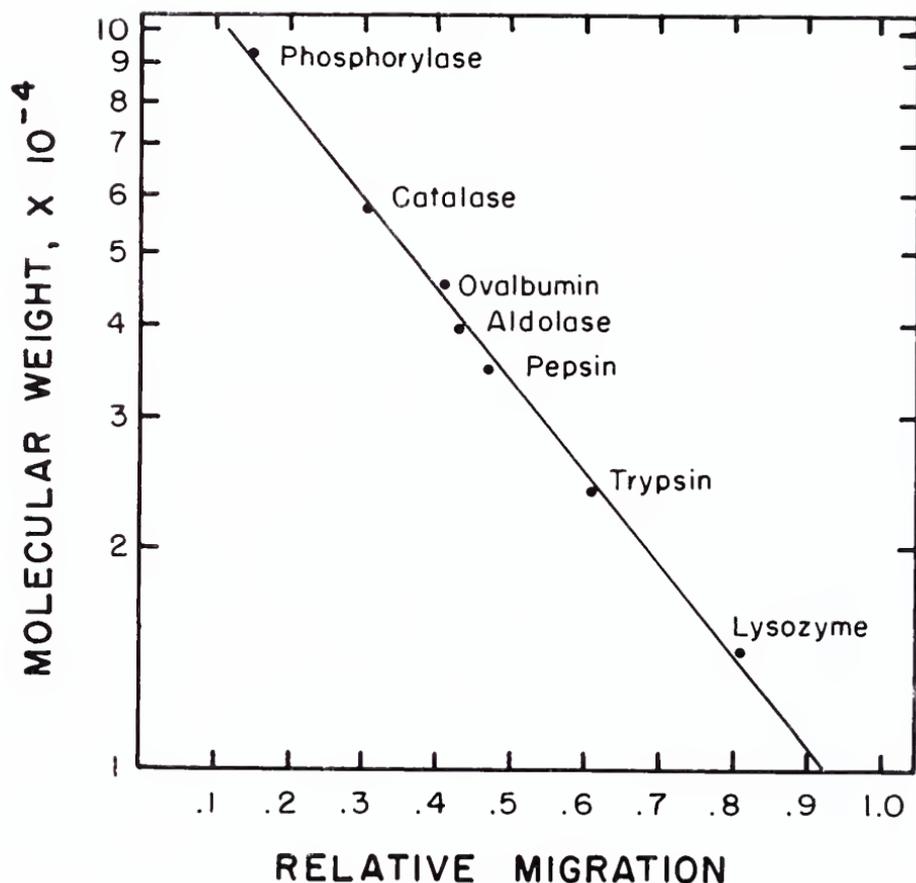


Figure 1. Standard curve calculated from marker proteins for estimation of molecular weight by SDS-PAGE.

14-15 bands ranged from 11,600 to 87,100 (Table 1), which generally agrees with ranges reported for protein profiles of unsonicated virions of the two viruses (2, 21). The major polypeptides of both viruses had MW of ca. 52,000, 36,500, and 32,500 (bands 6, 8, 9). Young and Lovell (21) found 12 polypeptides in unsonicated *T. ni* SEV virions with the two major bands having MW of 59,900 and 48,000. Similarly, Cibulsky et al. (2) reported 12 polypeptides for *T. ni* SEV, as well as for *P. includens* SEV; however, the two major polypeptides were in the 32,900-35,200 MW range. Differences in number, intensity, and MW of bands obtained in the above two studies and ours are probably due to procedural variations especially in relation to PIB solubilization and/or virion preparation (ultrasonication).

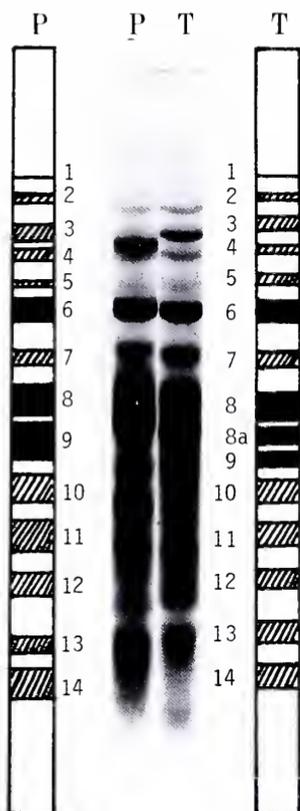


Figure 2. SDS-PAGE of ultrasonicated virions (25 μ g protein) of *Pseudoplusia includens* SEV (P) and *Trichoplusia ni* SEV (T). The direction of migration is toward the anode, from top to bottom. Polypeptide bands are numbered in order of migration, from 1 to 14.

Some minor but reproducible differences were apparent in the protein profiles of the two SEV. *T. ni* SEV virions contained a polypeptide (band 8a, MW 34,200) that was not detectable in *P. includens* SEV virions. Also, bands 3 and 4 consistently separated well in *T. ni* SEV preparations but not in those of *P. includens* SEV.

Virions of *T. ni* SEV and *P. includens* SEV can be differentiated serologically (13) and by cross-infectivity assays (6). Results reported here indicate that the viruses can also be distinguished by SDS-PAGE analysis of ultrasonicated virions.

Gel Electrophoresis of Polyhedrosis Viruses

Table 1. Estimated molecular weights of polypeptides separated by SDS-PAGE of ultrasonicated virions.

Virion protein	Molecular weight ($\times 10^3$ dalton) ^a	
	<i>Pseudoplusia includens</i> SEV	<i>Trichoplusia ni</i> SEV
1	86.7 \pm 0.8	87.1 \pm 0.5
2	78.0 \pm 0.5	79.9 \pm 2.5
3	69.7 \pm 1.6	71.3 \pm 1.1
4	66.5 \pm 0.8	65.7 \pm 0.6
5	58.1 \pm 0.6	58.0 \pm 1.7
6	52.1 \pm 0.8	52.2 \pm 0.5
7	43.1 \pm 2.4	43.0 \pm 0.8
8	36.6 \pm 1.4	36.5 \pm 0.8
8a		34.2 \pm 0.5
9	33.0 \pm 0.1	32.5 \pm 0.8
10	27.6 \pm 0.3	26.5 \pm 0.5
11	23.5 \pm 0.8	23.1 \pm 0.9
12	19.3 \pm 0.8	19.0 \pm 1.0
13	15.5 \pm 0.7	15.9 \pm 1.1
14	11.6 \pm 0.7	13.6 \pm 0.3

^aMean value and the standard deviation for five replicates; rounded to the nearest hundred.

LITERATURE CITED

1. Cibulsky, R. J., J. D. Harper, and R. T. Gudauskas. 1977. Biochemical comparison of polyhedral protein from five nuclear polyhedrosis viruses infecting plusiine larvae (Lepidoptera: Noctuidae). *J. Invertebr. Pathol.* 29:182-191.
2. Cibulsky, R. J., J. D. Harper, and R. T. Gudauskas. 1977. Biochemical comparison of virion proteins from five nuclear polyhedrosis viruses infecting plusiine larvae (Lepidoptera: Noctuidae). *J. Invertebr. Pathol.* 30:303-313.
3. Eppstein, D. A., and J. A. Thoma. 1975. Alkaline protease associated with the matrix protein of a virus infecting the cabbage looper. *Biochem. Biophys. Res. Commun.* 62:478-484.
4. Eppstein, D. A., and J. A. Thoma. 1977. Characterization and serology of the matrix protein from a nuclear-polyhedrosis virus of *Trichoplusia ni* before and after degradation by an endogenous proteinase. *Biochem. J.* 167:321-332.
5. Eppstein, D. A., J. A. Thoma, H. A. Scott, and S. Y. Young, III. 1975. Degradation of matrix protein from a nuclear-polyhedrosis virus of *Trichoplusia ni* by an endogenous protease. *Virology* 67: 591-594.

6. Harper, J. D. 1976. Cross-infectivity of six plusiine nuclear polyhedrosis virus isolates to plusiine hosts. *J. Invertebr. Pathol.* 27:275-277.
7. Kozlov, E. A., N. M. Sidorova, and S. B. Serebryani. 1975. Proteolytic cleavage of polyhedral protein during dissolution of inclusion bodies of the nuclear polyhedrosis viruses of *Bombyx mori* and *Galleria mellonella* under alkaline conditions. *J. Invertebr. Pathol.* 25:97-101.
8. Lowry, O. H., N. J. Rosebrough, A. L. Farr, and R. J. Randall. 1951. Protein measurement with the folin phenol reagent. *J. Biol. Chem.* 193:265-275.
9. Maruniak, J. E., M. D. Summers, L. A. Falcon, and G. E. Smith. 1979. *Autographa californica* nuclear polyhedrosis virus structural proteins compared from *in vivo* and *in vitro* sources. *Intervirology* 11:82-88.
10. McCarthy, W. J., and R. A. DiCapua. 1979. Characterization of solubilized proteins from tissue culture- and host-derived nuclear polyhedra of *Lymantria dispar* and *Autographa californica*. *Intervirology* 11:174-181.
11. McCarthy, W. J., and S. Y. Liu. 1976. Electrophoretic and serological characterization of *Porthetria dispar* polyhedron protein. *J. Invertebr. Pathol.* 28:57-65.
12. Padhi, S. B., E. F. Eikenberry, and T. Chase, Jr. 1975. Electrophoresis of the proteins of the nuclear polyhedrosis virus of *Porthetria dispar*. *Intervirology* 4:333-345.
13. Pritchett, D. W., H. A. Scott, and S. Y. Young, III. 1979. Serological relationships of five nuclear polyhedrosis viruses from lepidopterous species. *J. Invertebr. Pathol.* 33:183-188.
14. Scott, H. A., S. Y. Young, III, and J. A. McMasters. 1971. Isolation and some properties of components of nuclear polyhedra from the cabbage looper, *Trichoplusia ni*. *J. Invertebr. Pathol.* 18:177-182.
15. Shapiro, A. L., E. Vinuela, and J. V. Maizel. 1967. Molecular weight estimation of polypeptide chains by electrophoresis in SDS-polyacrylamide gels. *Biochem. Biophys. Res. Commun.* 28:815-820.
16. Singh, S. P., R. T. Gudauskas, and J. D. Harper. 1979. Serological comparison of polyhedron protein and virions from four nuclear polyhedrosis viruses of plusiine larvae (Lepidoptera: Noctuidae). *J. Invertebr. Pathol.* 33:19-30.
17. Summers, M. D., R. Engler, L. A. Falcon, and P. V. Vail (Eds.). 1975. Baculoviruses for insect pest control: safety considerations. EPA-USDA Working Symposium, Bethesda, MD. *Amer. Soc. Microbiol.* 186 p.

Gel Electrophoresis of Polyhedrosis Viruses

18. Summers, M. D., and G. E. Smith. 1978. Baculoviruses structural polypeptides. *Virology* 84:390-402.
19. Vlak, J. M. 1979. The proteins of nonoccluded *Autographa californica* nuclear polyhedrosis virus produced in an established cell line of *Spodoptera frugiperda*. *J. Invertebr. Pathol.* 34:110-118.
20. Weber, K., and M. Osborn. 1969. The reliability of molecular weight determinations by dodecyl sulfate-polyacrylamide gel electrophoresis. *J. Biol. Chem.* 244:4406-4412.
21. Young, S. Y., III, and J. S. Lovell. 1973. Virion proteins of the *Trichoplusia ni* nuclear polyhedrosis virus. *J. Invertebr. Pathol.* 22:471-472.

LATERAL ORANGE COLORATION IN FEMALE *SCELOPORUS UNDULATUS*:
VARIABILITY AND REFRACTORINESS TO OVARIAN STEROIDS¹

William E. Cooper, Jr. and C. Lynn Garthright

Department of Biology
Auburn University at Montgomery
Montgomery, AL 36193

Among samples of *Sceloporus undulatus* collected in southeastern Autauga County, Wind Creek Canyon, and Mount Cheaha during 1979 were several individuals showing small orange spots along both sides. The spots were most pronounced in the abdominal region but extended onto the thorax. There is often a suffusion of rusty coloration on the dorsum and lateral surfaces of fence lizards in Alabama (Mount, 1975), but the spots are discrete patches of a distinct hue. One female also had a small patch of brilliant orange color covering several scales near the center of the ventrum. Since the lateral orange spots of *S. undulatus* were somewhat similar to those developed by *Crotaphytus collaris* shortly before ovulation (Ferguson, 1976), it seemed possible that similar physiological mechanisms might regulate the deposition of orange pigment in the two species.

Previous studies have shown that steroid hormones induce orange spotting in female *C. collaris*. The spots may be artificially induced within 10 days by a series of daily progesterone injections (Cooper and Ferguson, 1972b). Estrogen alone does not induce the orange spotting. However, it hastens the effectiveness of progesterone. Thus, after a series of daily estrogen injections, the onset of color change in response to progesterone occurs several days sooner than if estrogen is withheld (Cooper and Ferguson, 1973). Testosterone, although not synthesized by saurian ovaries in substantial quantities, is a strong inductor of the orange spots. It is slightly less effective than progesterone (Cooper and Ferguson, 1972a) and probably is active due to the close similarity of its molecular structure to that of progesterone. Similar hormonal induction of color change has been reported in the related species, *Crotaphytus wislizeni*. Females injected with progesterone or follicle stimulating hormone develop a red-orange coloration. Estrogenic priming of the progestational effect likewise occurs (Medica et al., 1973).

A preliminary investigation of variability in orange spotting of *S. undulatus* was undertaken using the orangeness scale developed by Cooper and Ferguson (1972b). The brightest spot on each lizard was compared

¹Manuscript received 31 January 1980; accepted 25 April 1980.

Lateral Orange Coloration in *S. undulatus*

with chips from the Munsell Glossy Collection (Munsell Color Co., 2441 N. Calvert St., Baltimore, Maryland 21218) to determine orangeness rank on a scale from 1 to 10. Increase in orangeness rank represents a concurrent change in dominant wavelength toward red and an increase in percent saturation. Despite the absence of information regarding possible temporal changes in the orange spots of female fence lizards, especially those associated with reproduction, pilot experiments were designed to reveal potential roles of ovarian steroids.

Eighteen females were collected in Autauga County between 8/6 and 8/10, 1979, and along the rim and upper slope of Wind Creek Canyon on 9/4/79. These were maintained on mealworms and crickets until 9/25 when orangeness was measured and endocrine injections were initiated. The introduced hormones produced no detectable changes in orangeness rank. Prolonged daily administration of estrogen (estradiol 17- β) or progesterone (50 μ g/day in .05 cc cottonseed oil) was without effect, as was an initial series of daily estrogen injections succeeded by a series of daily progesterone injections. Although the major ovarian steroids do not appear to be responsible for individual differences in orange spot coloration, the possibility of a hormonal influence is by no means excluded. Pituitary gonadotropins would seem to be the most likely candidates for such a role if the orangeness were shown to vary with reproductive condition. This covariation of hormones and orange coloration is purely hypothetical since all females were reproductively inactive when studied during the fall.

On September 25, prior to any hormonal injections, the female *S. undulatus* showed considerable interindividual variation in orangeness, with most individuals at the lowest ranks, but with two at the highest (Table 1). Over a period of days, some individuals showed slight increases or decreases in orangeness rank, but since similar changes occurred in controls as well as experimental animals, the shifts appeared in no way systematically related to the injections. The changes instead seemed to be associated with molting and with temporal variation in darkness of the background skin color.

Table 1. Orangeness data for female *Sceloporus undulatus* on 9/25/79.

Chip designation	Orangeness rank	Dominant wavelength	Percent saturation	Number of females
5YR 9/2	1	584	11	5
7.5YR 9/2	2	581	13	10
7.5YR 8/6	4	583	40	1
5YR 7/14	10	588	84.5	2

Available evidence is sufficient only for the conclusions that substantial variation in orange spotting exists between individual females and that orangeness is not readily increased by the major ovarian

steroids. In this regard, *Sceloporus undulatus* differs markedly from *Crotaphytus collaris* and *C. wislizenii*. The latter two species show pronounced development of the colors prior to ovulation and retain the bright pigmentation while gravid. Because females of the more intensively studied *Sceloporus undulatus* have not been reported to show similar reproductively associated color changes, the results here reported are not surprising. The scant data available suggest that orangeness rank is determined primarily by fairly stable individual differences rather than by variation in reproductive state. It is not yet possible to conclude that the individual differences are heritable, but genetically determined interpopulational differences in orangeness are highly probable in a species with such extensive geographic variability. Future field observations during the reproductive season should reveal any relationship between cyclicity and development of orange spots. Orange color in female fence lizards is not unique to *Sceloporus undulatus*. Some female *S. graciosus* possess orange-red ventrolateral bands (Smith, 1946). Female *S. virgatus* develop orange throat patches during breeding season which are most intense in gravid specimens (Vinegar, 1972), suggesting a hormonal influence. It is possible that a polymorphism for production of orange coloration exists in the *S. undulatus* populations studied, explaining the bright orange ventral scales observed on one female. Individuals with the capacity to manufacture orange pigment may do so in response to reproductive hormones.

We wish to acknowledge the valuable assistance of Ken Marion, who provided field expertise and companionship on the collecting trip to Wind Creek Canyon, and of Gary Ferguson, who provided the Munsell color chips. This work was partially supported by a grant-in-aid from Auburn University at Montgomery.

LITERATURE CITED

- Cooper, W. E., Jr., and G. W. Ferguson. 1972a. Relative effectiveness of progesterone and testosterone as inducers of orange spotting in female collared lizards. *Herpetologica* 28:64-65.
- _____. 1972b. Steroids and color change during gravidity in the lizard *Crotaphytus collaris*. *General and Comparative Endocrinology* 18:69-72.
- _____. 1973. Estrogenic priming of color change induced by progesterone in the collared lizard, *Crotaphytus collaris*. *Herpetologica* 29: 107-110.
- Ferguson, G. W. 1976. Color change and reproductive cycling in female collared lizards (*Crotaphytus collaris*). *Copeia* 1976:491-494.
- Medica, P. A., F. B. Turner, and D. D. Smith. 1973. Hormonal induction of color change in female leopard lizards, *Crotaphytus wislizenii*. *Copeia* 1973:658-661.
- Mount, R. H. 1975. The reptiles and amphibians of Alabama. Auburn University Agricultural Experiment Station, Auburn, Alabama. vii+347 pp.

Lateral Orange Coloration in *S. undulatus*

- Smith, H. M. 1946. Handbook of lizards. Cornell University Press, Ithaca, New York. xxi+557 pp.
- Vinegar, M. B. 1972. The function of breeding coloration in the lizard, *Sceloporus virgatus*. Copeia 1972:660-664.

NOTES

NOTES

THE JOURNAL
OF THE
ALABAMA ACADEMY
OF SCIENCE

AFFILIATED WITH THE
AMERICAN ASSOCIATION FOR THE
ADVANCEMENT OF SCIENCE

VOLUME 51

OCTOBER, 1980

NO. 4

EDITOR:

W. H. Mason, General Biology, Auburn University, AL 36849

ARCHIVIST:

R. G. Eaves, Department of History, Auburn University, AL 36849

EDITORIAL BOARD:

R. T. Gudauskas, Chairman, Department of Botany and Microbiology, Auburn University, AL 36849

E. A. Curl, Department of Botany and Microbiology, Auburn University, AL 36849

W. W. Paudler, Department of Chemistry, University of Alabama, University, AL 35486

ADVISORY BOARD:

W. L. Alford, Auburn University

Charles Baugh, Univ. of South Alabama

G. F. Brockman, Univ. Ala., B'ham

R. J. Fornaro, Univ. South Alabama

A. Wayne Lacy, Auburn Univ., Mtgy.

E. M. Wilson, Univ. South Alabama

Walker H. Land, Jr., IBM

H. S. Marks, N. E. St. Jr. Col.

M. Miller, Univ. South Alabama

W. W. Paudler, UA, Tuscaloosa

Dan Whitson, Decatur

The Journal is the official publication of the Alabama Academy of Science, and is indexed in Biological Abstracts, Chemical Abstracts, America: History and Life, and Historical Abstracts.

Publication and Subscription Policies

Submission of Manuscripts. Submit all manuscripts and pertinent correspondence to the EDITOR. Each manuscript will receive two simultaneous reviews. For style details, follow Instruction to Authors, J. Ala. Acad. Sci. 50:96-97, 1979.

Reprints: Requests for reprints must be addressed to authors.

Subscriptions and Journal Exchanges: Address all correspondence to the CHAIRMAN OF THE EDITORIAL BOARD.

Advertising, News Releases: Advertisements and news releases will not be published in the Journal.

ISSN 002-4112

CONTENTS

ARTICLES

Objective Credit Scoring--An Analysis of Agricultural Borrower Characteristics Johno B. Weed and William E. Hardy, Jr.	260
Power Logistic Population Growth William E. Cooper, Jr.	273
Bacteriological Assessment of Aldridge Creek and Other Huntsville, Alabama Streams Telse A. Platt and Zoe A. Evans	280
Concepts of Present Self, Ideal Self, and Self in Five Years for Female and Male Students in Introductory Anthropology Avery G. Church	290
The Status of Public Employee Labor-Management Relations in Alabama George Munchus III	298
Wright Austin Gardner Emmett B. Carmichael	308
INDEX	315

OBJECTIVE CREDIT SCORING--AN ANALYSIS OF
AGRICULTURAL BORROWER CHARACTERISTICS^{1,2}

Johno B. Weed³ and William E. Hardy, Jr.
Department of Agricultural Economics and Rural Sociology
Auburn University
Auburn University, AL 36849

INTRODUCTION

Agriculture as an industry has undergone many changes in the past decade. One of the more significant changes has been the increased use of credit to finance production and capital expenses. This change is exemplified by the fact that outstanding farm debt has more than doubled since 1970, rising at an average annual rate of 12 percent. Though total farm investment has increased, net farm income has not increased as greatly creating a higher relative debt burden for farm operators [1].

This increase in debt load carried by farmers has made farm financing more difficult for the agricultural lender. Narrow income to expense margins, increased average size of loans, and increased number of loans have made the agricultural lender increasingly aware of the need to determine how borrower and agricultural business characteristics are related to the ability of farmers to repay their debts.

Most analyses of borrower's repayment ability are conducted via personal examination of individual credit files by credit analysts and loan officers. Considerable time is required to determine the risk associated with particular loans. As this risk increases, so does the necessity to better recognize a borrower's potential for long-run success as well as current debt repayment ability.

¹Manuscript received 17 September 1979; accepted 25 February 1980.

²Research on which this report is based was supported by Federal and State research funds under Hatch Project Ala-476. This report was selected as the outstanding student paper in the Economics Section of the 1979 Annual Meeting of the Alabama Academy of Science. The authors wish to thank the editor and the anonymous reviewers for helpful and constructive comments. Any errors or omissions are the responsibility of the authors.

³Former Graduate Research Assistant, Department of Agricultural Economics and Rural Sociology, Auburn University.

Objective Credit Scoring

The research results presented in this paper come from a study designed to develop an objective credit evaluation technique based on loan repayment ability characteristics of farm borrowers. Such techniques are valuable supplemental tools in loan analysis. They assist the lender in evaluating quantifiable variables that might aid in discriminating between borrowers that would be acceptable and those that would turn out to be weak or have problems in repayment. Such tools, however, do not replace the subjective judgement of a trained and experienced credit analyst.

PREVIOUS RESEARCH

Numerous methods have been utilized to evaluate relative financial and personal characteristics of borrowers; however, the most frequently used and most widely accepted method has been the statistical procedure known as multiple discriminant analysis.

The earliest application of discriminant analysis in credit scoring was undertaken by Durand [5]. He analyzed selected data from commercial banks and other consumer finance institutions financing the purchase of used cars. With these data, he developed an effective four variable credit scoring model to classify the borrowers as either acceptable or unacceptable. The model included the following variables: the amount of down payment, the price of the car, the monthly income of the buyer, and the length of the contract.

The use of ratios in addition to other data describing the borrower was emphasized by Hoskin in a study designed to predict risk in corporate bonds [7]. His model, developed through the use of regression analysis, effectively predicted the long-term credit standing of a business. From the study, he concluded that financial ratios are approximately normally distributed, are highly correlated with each other and highly correlated over time. These conclusions are significant to the increased use of financial ratios in discriminant analysis and the increased confidence that they are good predictors and meet the assumptions necessary for discriminant analysis.

Churchill described the alternatives that a firm has in selecting the type of credit scoring system to use [3]. He indicated that a firm could operate from the extremes of having credit scoring for each customer category to having a single system covering all types of accounts. The single model approach would be the least expensive to develop and administer, but would also probably have lower predictive power than a multi-model system. Churchill suggested that cluster analysis might be used to test the homogeneity of data or groupings of data to determine how many systems would be necessary to give maximum predictability.

Application of discriminant analysis to the classification of agriculturally related loans has been accomplished by several researchers. Bauer and Jordan collected data on 40 good and 43 problem loans from the period 1958-69 from two eastern Tennessee Production Credit Associations [2]. No attempt was made to identify subsets of the data that might have affected the overall effectiveness of the analysis. They used step-wise multiple regression analysis to find the most significant

variables and multiple discriminant analysis to find coefficients for these variables. Variables found to be significant were: total debt divided by total assets, reasonable farm value, total liabilities, marital status, family expense as percent of total farm expense, and current liabilities divided by current assets. Statistical analysis suggested the function should correctly classify 85 percent of the loans.

Johnson and Hagan evaluated the financial position and progress of 240 acceptable and 68 problem borrowers from three central and north-western Missouri Production Credit Associations [8]. A linear discriminant model was developed containing the following six significant ratio variables: loan repayment made plus marketable inventory divided by loan repayment anticipated, current assets divided by current debts, total debt divided by total assets, net worth divided by total debt, gross farm income divided by current debts, and net worth divided by loan commitment. The model correctly classified 62 percent of the loans analyzed.

Dunn developed a credit scoring model using 60 acceptable and 39 problem loans from Production Credit Association loan applications for the cash grain area of central Illinois [4]. The data were obtained from applications of borrowers who were new loan applicants between 1964-68 and who still had loans outstanding in 1971. Step-wise discriminant analysis was used to determine the variables and their respective coefficients that most significantly distinguished between acceptable and problem loans. The final model contained four significant variables; total debt divided by total assets, amount of loan insurance, amount of note divided by total assets, amount of note divided by net cash farm income, and acres owned. The model correctly classified 90 percent of the acceptable loans and 60 percent of the problem loans.

DATA ASSIMILATION

Data used in this study were collected from loan applications of borrowers at all eight Production Credit Associations located in Alabama, thus giving a cross-sectional sample of the Alabama farm borrower. Each association president was requested to randomly select a sample of 40 loans including both acceptable and problem loans.

Acceptable loans are those that require only normal supervision. This group contained loans ranging from those with no obvious deficiencies or credit problems, to those having such significant credit weaknesses that they must be backed up by member equity to assure repayment performance and to maintain or improve the likelihood of loan repayment.

Problem loans are weak loans in that they possess serious credit deficiencies and require more than normal supervision either to improve repayment standards or to liquidate on schedule. These loan accounts may contain factors such as low equity position, unwise use of credit, adverse trends, or faulty management.

From the data set of 220 loan applications, a test subsample of 25 problem and 25 acceptable loans were drawn. This left a sample of 52 problem and 118 acceptable loans for analysis.

Objective Credit Scoring

Borrower characteristics from the sample provided raw data necessary for the construction of the fifteen variables for analysis. Farm income data could not be included in the analysis because only 60 percent of the data set contained such information. Three non-ratio variables were drawn directly from the data. These were:

1. Age of operator,
2. Acres owned, and
3. Acres rented.

In addition, twelve financial ratios were developed. These were:

1. Current assets divided by current liabilities,
2. Current liabilities divided by total liabilities,
3. Total loan commitment divided by current assets,
4. Underlying security value divided by total loan commitment,
5. Total repayment made divided by loan repayment anticipated,
6. Loan repayment made plus marketable inventory divided by loan repayment anticipated,
7. Loan repayment anticipated divided by total assets,
8. Total liabilities divided by net worth,
9. Total assets divided by net worth,
10. Current liabilities divided by net worth,
11. Total loan commitment divided by net worth, and
12. Total liabilities divided by total assets.

Many of the variables used in this study were found in previous research. Some were found to be significant in discriminating between acceptable and problem loans. Other variables have been presented in financial analysis literature as being useful in evaluating financial stability and success [9]. Some variables were developed based on data availability and the desires of the researchers to evaluate any factor having strong theoretical justification for potentially classifying acceptable loans.¹

Operator's age was used to reflect the life stage of the farmer. This factor represents a proxy of the farmer's view of credit use. Acres owned and acres rented were felt to be important because they reflect the size of the farming operation.

The twelve financial ratio variables may be viewed as measures of liquidity and solvency. Variables one through seven are related to the capacity of the farm business to meet financial obligations as they come due. This ability is shown directly by the current ratio, current assets divided by current liabilities.

¹Variables related to projected gross and net income, which would have given measures of profitability, would have likely been important in the discriminating process; however, only 60 percent of the sample included such information. Elimination of 40 percent of the observations would have severely limited the amount of data available for analysis.

Current liabilities divided by total liabilities and total loan commitment divided by current assets give an indication of debt structure. These variables emphasize the amount of debt due and the amount that can be covered in the current time period. Underlying security value divided by total loan commitment is a measure of the ability of the collateral to liquidate the loan.

Variables five, six, and seven all include loan repayment and serve as a measure of performance. These variables are directly related to income generating ability.

Total liabilities divided by net worth is one of the most often used indicators of solvency, or the ability of all assets to cover all debts. It is commonly referred to as the leverage ratio. As the amount of borrowed capital increases relative to equity capital, risk for the lender generally increases.

Variables nine, ten, and eleven are also related to the amount of owner's equity and give a measure of the relative amount of financial commitment the owner has in the operation. The final variable, total liabilities divided by total assets, a direct indicator of solvency, shows the ability of the value of the total farming operation to cover its debts and measures long-term financial strength.

Obviously, many of these variables are interrelated and serious correlation problems would have arisen had they all been used in a model concurrently. To minimize this problem, special attention was given to correlation coefficients and any significantly correlated variables were removed before final estimation of the model.

PROCEDURE AND RESULTS OF ANALYSIS

Examination of Data Homogeneity

Cluster analysis is a statistical technique that may be used to search for natural groupings in a dataset or population. It provides the tool to empirically investigate a dataset in order to discover any distinct subsets within the data. Clusters are combined according to the distance between clusters with this distance being determined by the following equation:

$$D_{jg} = [\sum_i (x_{ji} - x_{gi})^2]^{1/2}$$

Where:

D_{jg} = the distance between observation X_j and X_g ,

x_{ji} = the i^{th} variable of observation X_j , and

x_{gi} = the i^{th} variable of observation X_g [1].

Although there are no sound statistical tests for evaluating the clusters formed, summary statistics such as the mean and variance for

Objective Credit Scoring

each variable in each cluster will help to identify the differences between clusters. Even though the evaluation of clustering results is difficult, the contribution to the researcher's recognition of patterns or problem characteristics embedded in the sample justifies its use.

This technique was used in this analysis to determine if there were any natural groupings within the data that would bias the discriminant function. Full-time as compared to part-time farmers and the different types of farmers as categorized by their major enterprises were analyzed to see if there were any natural groupings for classification purposes.

Variables included in the cluster analysis were the twelve financial ratio variables, the three non-ratio variables, and the variable indicating membership in either the acceptable loan category or the problem loan category. Results of the analysis indicated that there was no significant difference between full-time and part-time farm borrowers for classification purposes with the variables used in this analysis and that there was no significant difference between borrowers with different types of farms.

Procedure for Credit Scoring

Discriminant analysis is a statistical technique used for classifying an item into one of several classes on the basis of certain characteristics. In order to do this, one or more discriminant functions are derived. These relationships are of the form:

$$Y = B_1X_1 + B_2X_2 + B_3X_3 + \dots + B_kX_k$$

Where:

Y = the value of the linear combination of k variables,

B_i = the coefficients of the k variables in the linear combination, and

X_i = the variables used for discrimination.

The objective of linear discriminant analysis is to choose the values of the B coefficients that will enable Y to serve as the optimal discriminator between the groups. In order for Y to be an optimal discriminator, the B coefficients must be chosen in such a way that the differences between the group means per unit of dispersion about those means are maximized [6].

In working with sample data, there are two problems that can arise to retard optimum discrimination. Often there are more discriminating variables in a model than necessary to achieve satisfactory discrimination. Also, if there is high correlation between variables, the discriminant coefficients will be unstable and difficult to interpret.

In both of the above situations, it is desired that the most useful of the available variables be selected. A step-wise procedure can be

used to reduce the number of variables in the discriminant function and eliminate highly correlated variables.

In order to test whether the calculated coefficients and their associated variables successfully discriminate between the two groups, the F-test is used. If the calculated F-value is greater than the appropriate F-critical value, the discriminant function significantly discriminates between the two groups.

The cut-off point between the two group means must be determined so that an element outside the sample can be classified. Assuming that the two kinds of errors, that is, classifying a problem loan (group P) as acceptable, and classifying an acceptable loan (group A) as problem are of equal significance, the cut-off point can be determined by the equation:

$$Y_c = \frac{S_p Y_a + S_a Y_p}{S_p + S_a}$$

Where:

Y_c = the calculated cut-off score,

S_p = the standard deviation of the Y-values for group P,

S_a = the standard deviation of the Y-values for group A,

Y_p = the mean Y-value for group P, and

Y_a = the mean Y-value for group A.

The calculated cut-off point can be tested to determine how well it would correctly classify each group by deriving Z statistics and referring the calculated statistics to a "Normal Frequency Distribution Table." The Z statistics are calculated by:

$$Z_p = \frac{Y_c - \bar{Y}_p}{S_p} \quad \text{and} \quad Z_a = \frac{Y_c - \bar{Y}_a}{S_a}$$

Development of Credit Scoring Model

After analysis of all fifteen variables with step-wise multiple discriminant analysis, only two proved to be significant at the 95 percent confidence level: total liabilities divided by total assets and annual loan repayment anticipated divided by total assets. The developed function had an F-ratio that was significant above the 99 percent level and correlation between the two variables was not significant. The equation was as follows:

$$Y_s = 186.0 - 460.8X_1 - 161.2X_2$$

Objective Credit Scoring

Where:

Y_s = the calculated discriminant score which distinguishes between acceptable and problem loans,

X_1 = total liabilities divided by total assets, and

X_2 = loan repayment anticipated divided by total assets.

Variable X_1 , total liabilities divided by total assets, is a solvency measure indicating the overall financial stability and strength of the farm organization. Obviously, as the level of liabilities increases relative to the total level of assets, financial risk for the business increases and would justify a lower credit score.

Loan repayment anticipated divided by total assets, variable X_2 , is a liquidity related concept and gives a measure of financial pressure being placed upon the production capacity of the firm. Again, as the value of this relationship increases, the credit score would be reduced and the risk associated with the loan would increase.

The critical cut-off value of Y is needed to classify agricultural loans with the developed discriminant function. If it is assumed that misclassification of acceptable and problem loans are of equal significance, the cut-off value would be -20.2. Given this calculated cut-off score, those loans with computed Y values equal to or greater than -20.2 would be classified as acceptable loans, while those with Y values less than -20.2 would be classified as problem loans.

To determine how well this cut-off point should discriminate, the Z -values for the Y_c values of each group were calculated. For the calculated Z values of -0.73 and 0.73, a "Normal Frequency Distribution Table" indicated that the developed discriminant function should correctly classify at least 76.7 percent of all loans.

In order to additionally verify how well the function could actually classify loans into either acceptable or problem loan groups, the computed discriminant function and critical cut-off value were applied to the holdout sample of 50 loan applications. The function classified 84 percent of the acceptable loans correctly, 92 percent of the problem loans correctly, and 88 percent of the total.

In determining the cut-off score, the significance of the consequences of misclassifying both problem and acceptable loans was considered. If the consequences of the two possible classification errors are of equal significance then the Z statistic will be equal for both classification errors. However, since all problem loans need close supervision and the consequences of misclassifying a problem loan could possibly be more costly than misclassifying an acceptable loan, a more precise cut-off score is needed that will reflect the negative consequences of problem loan misclassification.

This could be accomplished by selecting the desired percentage of problem loan classification error that would be suitable, consulting a

table of cumulative normal frequency distributions, and deriving the appropriate cut-off value through the following equation:

$$Y_e = \bar{Y}_p + (Z)S_p$$

Where:

Y_e = problem loan classification error selected cut-off value,

\bar{Y}_p = mean Y value for problem loan group,

Z = standard measure of normal distribution, and

S_p = standard deviation for problem loan group [10].

Calculated cut-off values for various selected percentages of misclassified problem loans and their effect on classification of the original sample collected are given in Table 1.

In order to use the table, an allowable percentage of problem loan misclassification has to be chosen. The corresponding computed cut-off value can then be used to classify loans with a probable assurance of misclassifying at most the chosen percentage of problem loans. An example

TABLE 1
CUT-OFF VALUES AND CLASSIFICATION RESULTS OF
TOTAL SAMPLE FOR SELECTED PROBLEM LOAN
MISCLASSIFICATION PERCENTAGES

Problem Loan Misclassification Percentage Selected	Computed Cut-Off Value	Percent Correct Classification		
		Problem	Acceptable	Total
50	-84.919	54.5	90.2	77.7
45	-73.414	55.8	87.6	75.9
40	-62.794	59.7	86.7	77.3
35	-50.404	64.9	86.0	78.6
30	-38.898	70.1	85.3	80.0
25	-25.623	81.8	81.1	81.4
23.3	-20.176	83.1	79.7	80.9
20	-10.578	84.4	79.0	80.9
15	7.122	89.6	69.2	76.4
10	28.362	92.2	60.8	71.8
5	60.223	93.5	44.8	61.8
2.5	88.543	97.0	29.4	53.2
2	96.508	97.4	26.6	51.4
1	121.288	98.7	11.9	42.3

Objective Credit Scoring

would be to assume that only one percent of problem loans can be misclassified, then the corresponding cut-off value would be 121.288. Using this cut-off value, the discriminant function would misclassify at most one percent of the problem loans. However, as can be seen from the results of the classification test, if 99 percent of the problem loans are correctly classified, only 12 percent of the acceptable loans are correctly classified. There is a trade-off between the correct classification of problem and acceptable loans. An increase in the percentage of misclassification of problem loans will cause a decrease in the percentage of misclassification of acceptable loans.

The trade-off of correct classification can be better seen in Figure 1. The X-axis is allowable problem loan misclassification percentage and the Y-axis is actual percent of correct classification. As pointed out earlier, the percent of acceptable loans correctly classified increases for each decrease in the percent of problem loans correctly classified. As the problem loan misclassification percentage decreases, total correct classification increases, reaches a maximum, and then decreases. It is interesting to note that all three lines intersect at the point of maximum total correct classification. This point is the optimum cut-off value for maximizing total correct classification with the developed discriminant function. The calculated cut-off score for the function had a probability of misclassifying 23.3 percent of the problem loans and is approaching optimum.

SUMMARY

The purpose of this study was to develop an objective loan evaluation technique that could be used in differentiating between acceptable and problem loans. Emphasis was directed toward evaluating agricultural loans made by the eight Production Credit Associations in Alabama. However, the overall results should also be interesting to and useful for farm borrowers and other agricultural lenders dealing with customers similar to those served by Production Credit Associations.

The analysis indicated that only two variables were significant, total liabilities divided by total assets and annual loan repayment anticipated divided by total assets. Total liabilities divided by total assets has been found to be significant in studies by Bauer and Jordan [2], Dunn [4], and Johnson and Hagan [8]. The amount of annual loan repayment anticipated divided by total assets had not been included as a variable in other studies.

Total liabilities divided by total assets contributed negatively toward borrower classification indicating that as this ratio increased, the probability of a loan being classified as acceptable decreased. Using the calculated cut-off value for the evaluation technique (-20.2), total liabilities divided by total assets taken by itself could not be greater than 0.447 for a loan to be classified as acceptable.

The second variable, annual loan repayment anticipated divided by total assets also had a negative effect on borrower classification. As this ratio increased, the probability of a loan being classified as

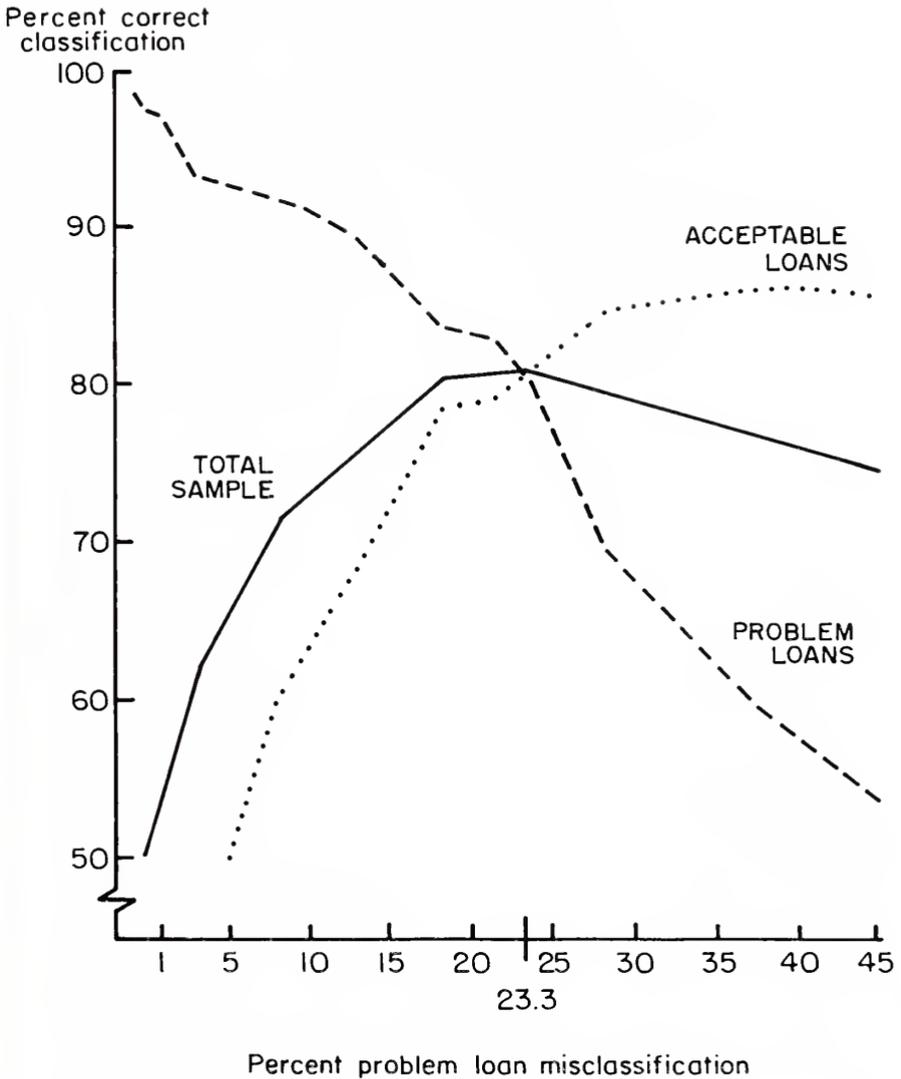


Figure 1. Percentages of Correct Classification for Acceptable, Problem, and Total Loans at Various Levels of Allowable Loan Misclassification

Objective Credit Scoring

acceptable decreased, indicating more stress on the farmer's assets to generate repayment capital.

Through the application of the derived table of cut-off values, the discriminant function can be used to classify loans with any selected problem loan misclassification percentage. The selected problem loan misclassification percentage can also be compared to the approximate acceptable loan correct classification percentage in order for cut-off value decisions to be made from comparison of misclassification, correct classification, and their associated cost. This cost would be determined by the lending institutions based on their estimates. Such a classification technique for classifying loan applications and existing loans would allow lending institutions to select cut-off values that would minimize the chance of misclassifying problem loans or maximize total loan volume, whichever was preferred.

The table of various cut-off values indicated the trade-off between correct classification of problem loans and correct classification of acceptable loans. As the percentage of correct classification of problem loans decreased, the percentage of total loans correctly classified increased, reached a maximum where correct classification of both loan groups were equal, and then decreased. The maximum percentage of correct classification of all loans was found to correspond to the cut-off value at which at least 75 percent of problem loans were correctly classified.

REFERENCES

- [1] Anderberg, Michael R. *Cluster Analysis for Applications*. New York: Academic Press, 1973.
- [2] Bauer, Larry L. and John P. Jordan. "A Statistical Technique for Classifying Loan Applications," University of Tennessee, Agricultural Experiment Station, Bulletin 476, 1971.
- [3] Churchill, Gilbert A. "Credit Scoring--How Many Systems Do We Need?" *Credit World*, Volume 66, November 1977, pp. 6-11.
- [4] Dunn, Daniel J. "Evaluating Potential Loan Outcomes Based on New Loan Applications for Illinois Cash-Grain Farms," Unpublished Master's Thesis, University of Illinois, 1974.
- [5] Durand, David. *Risk Elements in Consumer Installment Financing*. New York: National Bureau of Economic Research, 1941.
- [6] Eisenbeis, Robert A. *Discriminant Analysis and Classification Procedures*. Kentucky: D. C. Heath and Co., 1972.
- [7] Hoskin, Graydon J. "Some Aids to Establishing Grading Systems for Commercial Loans," *Journal of Commercial Bank Lending*, May 1968, pp. 24-30.

- [8] Johnson, Russell B. and Albert R. Hagan. "Agricultural Loan Evaluation with Discriminant Analysis," *Southern Journal of Agricultural Economics*, Volume 5, Number 2, December 1973, pp. 57-62.
- [9] Nelson, Aaron G., Warren F. Lee, and William G. Murray, *Agricultural Finance*. Ames: Iowa State Press, 1973.
- [10] Peters, William S. and George W. Summers. *Statistical Analysis for Business Decisions*. New Jersey: Prentice-Hall, 1968.
- [11] United States Department of Agriculture. *Agricultural Outlook, December 1978*. Washington: U.S. Government Printing Service, 1978.

POWER LOGISTIC POPULATION GROWTH^{1,2}

William E. Cooper, Jr.
Department of Biology
Auburn University at Montgomery
Montgomery, AL 36117

Abstract. A simple population growth model is presented which includes logistic and exponential growth as special cases. The power logistic equation is similar to the logistic with the exception that the number of individuals in the environmental resistance term may be raised to a variable power, θ , here called the density-dependence factor.

Carrying capacity is directly affected by changes in the exponent and is given by the carrying capacity of the logistic equation raised to a power equal to the reciprocal of the density-dependence factor. The exponent θ must therefore be greater than or equal to zero if rapid extinction is to be avoided.

In comparison with a logistically growing population, a population will be larger if $0 < \theta < 1$, but smaller if $\theta > 1$. Changes in θ produce changes in the form of population growth as well as in number. The growth curve appears flattened relative to the logistic for θ values greater than one. As θ decreases from one to zero, there is a gradual transformation of population growth from logistic to exponential. Growth is exponential when the density-dependence factor is zero and logistic when θ equals one.

Although a number of complex theoretical formulations of population growth are now available, ecology textbooks rely heavily on the logistic or Verhulst-Pearl equation (Verhulst, 1838; Pearl and Reed, 1920) to explain some general features of negative feedback of numbers on population growth. The logistic equation has also served as a starting point for models of interactions between populations, such as the Lotka-Volterra competition equations (Lotka, 1925; Volterra, 1926) and the Leslie-Gower predation model (Leslie and Gower, 1960).

In ecology texts (i.e., Odum, 1971; Krebs, 1978) the logistic equation is often given in the form

¹Manuscript received 11 September 1979; accepted 29 July 1980.

²This work was partially supported by a grant-in-aid from Auburn University at Montgomery.

$$\frac{dN}{dt} = rN\left[1 - \frac{N}{K}\right],$$

where N is the number of individuals in the population and r is a constant called intrinsic rate of increase. K is the carrying capacity of the environment, the fixed maximum number of individuals which may be in the population in the given environment.

This equation consists of exponential population growth, i.e.,

$$\frac{dN}{dt} = rN,$$

times a modifying factor $(K-N) \div K$ which is interpreted as the environmental resistance to unlimited exponential growth. As N approaches K , the overall population growth rate slows because $(K-N)/K$ approaches zero. At $N = K$, population growth ceases.

Although the logistic equation is widely used, it has several limitations, such as an unvarying carrying capacity and an absence of delay in altering growth rate in response to changing density. In spite of its limitations, there is experimental and field evidence that growth does sometimes follow a logistic path. Also, the logistic equation provides a concise and simple conceptual starting point which may be altered to study effects of various influences.

One less often noted limitation of the logistic equation is an assumption that exponential growth is slowed by an environmental resistance factor which is a linear function of N . Actually the resistance may take several forms. This note presents a discussion of one promising mathematical generalization in which the factor N in the environmental resistance factor may be raised to any power, which may be called the density-dependence factor. The variable power allows for all degrees of density-dependent mutual inhibition of population growth and for a variable carrying capacity.

Empirical population growth often follows a path similar to logistic growth, but with consistent departures such as being somewhat flattened or excessively accelerated. In laboratory studies of competing *Drosophila* systems, it was found that a modified Lotka-Volterra competition model of the form

$$\frac{dN_i}{dt} = r_i N_i \left[1 - (N_i/K_i)^{\theta_i} - \alpha_{ij} N_j/K_i \right]$$

closely approximated the growth rates of populations of *Drosophila willistoni* and *D. pseudoobscura* (Ayala, Gilpin, and Ehrenfeld, 1973; Gilpin and Ayala, 1973). Ayala *et al.* (1973) noted that the exponent, θ , in the above model and its restriction to a single species alters the relationship between population density and growth rate. In a subsequent paper, Gilpin, Case and Ayala (1976) analyzed certain biological consequences of growth according to the equation

$$\frac{dN}{dt} = rN\left[1 - \left(\frac{N}{K}\right)^{\theta}\right]. \quad (1)$$

Power Logistic Population Growth

They emphasized the importance of the density-dependence factor (θ) in selective regimes between the extremes of r and K selection. They also derived maximum growth rates.

From equation 1, we may find the maximum attainable population size by letting the derivative equal zero. When

$$\frac{dN}{dt} = rN \left[1 - \left(\frac{N}{K} \right)^\theta \right] = 0,$$

$N = K$. I.e., the asymptotic population value is simply the carrying capacity, assuming $\theta \neq 0$.

A slightly more general form of population growth is the power logistic equation

$$\frac{dN}{dt} = rN \left[1 - \frac{(N)^\theta}{K} \right] \quad (2)$$

which differs from equation 1 in that K is not raised to the arbitrary power, θ . This minor change allows wide variation of the asymptotic population size. Solving for this value, we have

$$\begin{aligned} rN \left[1 - \frac{(N)^\theta}{K} \right] &= 0, \\ N &= K^{(1/\theta)}, \quad \theta \neq 0. \end{aligned} \quad (3)$$

Equations 1 and 2 are equivalent only in the special case $\theta = 1$ (logistic growth).

Initially, it may seem strange to think that the final population size is not necessarily K , but it may be advantageous to do so. We interpret r to represent the maximal growth rate at low population density, the intrinsic rate of increase. K may similarly be considered to be the carrying capacity exclusively under logistic growth, when the environmental resistance is linear. For nonlinear growth ($\theta \neq 1$), the carrying capacity may be above or below K depending on the power to which N is raised in the environmental resistance factor. It is reasonable to suppose that the carrying capacity may be affected by the actual rate of growth of a population. Very rapidly growing populations ($\theta < 1$) might attain a final greater number with a preponderance of the population consisting of smaller and younger individuals. Growth slower than logistic might result in a reduced carrying capacity in a population relatively skewed towards larger and initially older individuals.

The power logistic population growth equation may be solved analytically for N at any specified time. Equation 2 is a separable differential equation for which the more complex integral may be solved by partial fractions using substitution $u = K - N$. The solution is

$$N_t = \left[\frac{KN_o^\theta e^{r\theta t}}{K - N_o^\theta + N_o^\theta e^{r\theta t}} \right]^{1/\theta}$$

From this equation it can be seen that the intrinsic rate of increase directly affects the exponential terms but has no effect on other aspects of power logistic growth. Specifically, the intrinsic rate of increase has no effect on carrying capacity, which depends only on the constants in the environmental resistance term, $1 - N^\theta/K$. It can readily be verified that the above solution of the power logistic equation includes solutions of the logistic as the special case in which $\theta = 1$. Substituting in the preceding equation, we have

$$\begin{aligned} N_t &= \frac{KN_0 e^{rt}}{K - N_0 + N_0 e^{rt}} \\ &= \frac{K}{1 + \left(\frac{K - N_0}{K}\right)e^{-rt}} \end{aligned}$$

which is a solution to the logistic equation.

It is thus possible to consider various environmental resistances in the equation developed here and to obtain logistic growth when the environmental resistance is linear. A family of population growth curves is generated by solving the power logistic equation using different density-dependence factors.

The power logistic equation also includes the exponential mode of growth in the original differential equation although in an unfamiliar form. When $\theta = 0$

$$\begin{aligned} \frac{dN}{dt} &= rN\left(1 - \frac{N^0}{K}\right) \\ &= r\left(1 - \frac{1}{K}\right)N, \end{aligned}$$

a formula for exponential growth with a modified rate constant. However, the general solution of the power logistic does not apply when $\theta = 0$ because $1/\theta$ is undefined in equation 3. The differential equation must be solved in exponential form to obtain

$$N_t = N_0 e^{r\left(1 - \frac{1}{K}\right)t}.$$

Consider again the effect of the density dependence factor, θ , on the carrying capacity, K^* . The carrying capacity was previously found to be $K^* = K^{1/\theta}$. Since K must be greater than 1 for the population to survive, the carrying capacity is less than K for $\theta > 1.0$. When θ is between zero and one, $1/\theta$ is greater than one, which corresponds to $K^* > K$. For θ equal to zero, the carrying capacity does not exist, which is true under exponential growth. Next consider negative exponents. If θ is between zero and minus one, the carrying capacity is less than one but greater than $1/K$. When the exponent is precisely minus 1,

$$K^* = \frac{1}{K}.$$

Power Logistic Population Growth

For density-dependence factors below minus one, the carrying capacity is less than $1/K$ but greater than zero. Since K is greater than one, $K^* = 1/K^\theta$. Thus the carrying capacity approaches 0 as $\theta \rightarrow -\infty$.

It is clear that whenever θ is negative, a population growing in a power logistic fashion will go extinct. We may therefore restrict further consideration to non-negative θ values. Population growth ceases at lower carrying capacities than in the logistic if the exponent θ in the power logistic's environmental resistance term is greater than one. When the exponent is positive but less than one, the population's carrying capacity is larger than with simple logistic growth. The carrying capacity increases greatly for very small exponents, and becomes infinitely large where the exponent is zero. In the latter case, the environmental resistance becomes density independent, whereas the resistance (and thus the instantaneous rate of population growth) is density-dependent at all non-zero values of the exponent (Table 1).

Table 1. Summary of the power logistic equation, its solution, and the relationship between the equation's exponent and the carrying capacity approached asymptotically by the population.

$$\frac{dN}{dt} = rN \left[1 - \frac{N^\theta}{K} \right]$$

$$N_t = \left[\frac{KN_0^\theta e^{r\theta t}}{K - N_0^\theta + N_0^\theta e^{r\theta t}} \right]^{1/\theta}$$

Exponent	Carrying Capacity (K^*)
$\theta > 1$	$< K$
$\theta = 1$	K
$0 < \theta < 1$	$> K$
$\theta = 0$	∞
$-1 < \theta < 0$	$> 1/K, < 1$
$\theta = -1$	$1/K$
$\theta < -1$	$< 1/K, > 0$

The solutions of a power logistic equation with a given set of constants generate a population growth curve. A family of such curves may be obtained by varying the density-dependence factor. Such a family of population curves is shown in Figure 1. The power logistic equation used here is the slightly more general form $dN/dt = rN(a - bN^\theta)$. For each curve, $r = 0.03$, $a = 0.85$, $b = 0.00095$, and $N_0 = 10.0$. Theta values for the curves range from 0 to 1.5. Note the typical logistic growth pattern when θ is equal to 1.0. The curve for $\theta = 1.5$ is considerably flattened. With decreasing θ values between 1 and zero,

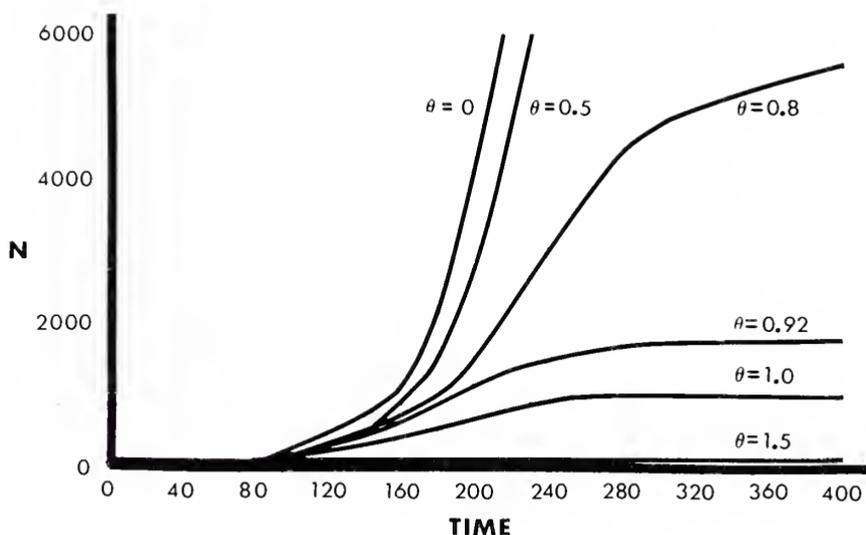


Figure 1. Rapidity of population growth and carrying capacity vary enormously over a relatively small range of power logistic density-dependence factors.

population growth is increasingly rapid. All curves save that with $\theta = 0$ eventually approach a carrying capacity as follows:

theta	1.5	1.0	0.92	0.80	0.50	0
carrying capacity	100	1000	1823	5623	1,000,000	∞

Note that the carrying capacity is more rapidly approached in a proportional sense with high theta values.

LITERATURE CITED

- Ayala, F. J., M. E. Gilpin, and J. G. Ehrenfeld. (1973). *Theoretical Population Biology* 4:331-356.
- Gilpin, M. E., and F. J. Ayala. (1973). *Proc. Nat. Acad. Sci. USA* 70 (12, part 1):3590-3593.
- Gilpin, M. E., T. J. Case, and F. J. Ayala. (1976). *Mathematical Biosciences* 32:131-139.
- Krebs, C. J. (1978). *Ecology: The experimental analysis of distribution and abundance*. Second Edition. Harper and Row, New York.
- Leslie, P. H., and J. C. Gower. (1960). *Biometrika* 47:219-234.

Power Logistic Population Growth

- Lotka, A. J. (1925). *Elements of Physical Biology*. Williams and Wilkins, Baltimore.
- Malthus, T. R. (1798). An essay on the principle of population as it affects the future improvement of society. Johnson, London.
- Odum, E. P. (1971). *Fundamentals of Ecology*. Third Edition. W. B. Saunders, Philadelphia.
- Pearl, R., and L. J. Reed. (1920). *Proc. Nat. Acad. Sci.* 6:275-288.
- Verhulst, P. F. (1838). *Corresp. Math. Phys.* 10:113-121. Translated in Kormondy, E. J. (ed.). (1965). *Readings in Ecology*. Prentice-Hall, Englewood Cliffs, New Jersey.
- Volterra, V. (1926). *Mem. Accad. Lincei.* 2:31-113.

BACTERIOLOGICAL ASSESSMENT OF ALDRIDGE CREEK AND
OTHER HUNTSVILLE, ALABAMA STREAMS^{1,2}

Telse A. Platt³ and Zoe A. Evans

*Department of Biology
University of Alabama in Huntsville
Huntsville, AL 35807*

Abstract. A survey was made to detect and identify enteric bacteria occurring at 12 sampling stations along Aldridge Creek and other streams in Huntsville, Alabama. Primary enteric pathogens were not isolated but numerous opportunistic pathogens were found. The most widely distributed enteric bacteria were species of *Enterobacter* which were found at all sampling stations. Potentially enteropathogenic strains of *Escherichia coli* were detected at 5 sites. Although total bacterial densities in Aldridge Creek were higher during warmer months than in the winter, some of the isolates exhibited seasonal variations in occurrence. The results indicate that fecal pollution is present in local streams and a potential public health risk is associated with waters from these streams.

INTRODUCTION

Enteric diseases are the most common bacterial illnesses transmitted by water. The etiologic agents of these diseases are discharged with the feces and infection results from ingestion of the bacteria in fecally contaminated water or food. Although the enteric pathogens responsible for typhoid fever, bacillary dysentery, and cholera are not commonly encountered in fresh waters in this country, opportunistic pathogens are sometimes found in streams and other bodies of water. These opportunists present a potential risk of infection to susceptible individuals coming in contact with large numbers of them and the possibility of waterborne disease transmission does exist, particularly if poor sanitation prevails.

Because isolation of the true enteric pathogens from water is often unsuccessful, indicator microorganisms are commonly used to determine the presence of fecal pollution and, consequently, the possible presence of enteric pathogens in water used for drinking and recreational purposes.

¹Manuscript received 27 March 1980; accepted 3 July 1980.

²Taken in part from a thesis submitted by T. A. Platt to the graduate school of the University of Alabama in Huntsville in partial fulfillment of the requirements for the M.S. degree in Biology.

³Present address: Ambulatory Care Center, University of Alabama in Huntsville.

Bacteriological Assessment of Aldridge Creek

The use of coliform bacteria as a measure of the sanitary quality of lakes and streams has been practiced for many years with varying degrees of success. The coliform group includes *Escherichia coli* and a heterogeneous mixture of lactose-fermenting Gram negative bacilli normally found in the intestinal tracts of humans and other warm-blooded animals or as free-living organisms on vegetation. Bacteriological examination of water for fecal pollution depends on the lactose-fermenting characteristic of these bacteria and differential and selective media are used to perform presumptive, confirmed, and completed tests for the presence of coliform bacilli (1). An indication of the number of bacteria present in a water source may be obtained with the multiple tube fermentation technique for estimation of the most probable number (MPN) of coliform bacteria present or by the plate count procedure or membrane filter technique for estimating bacterial densities (1).

Several investigators have questioned the use of coliform bacilli as an index of water quality and recent studies have shown that the presence of this group of bacteria, when used alone to detect pollution, may provide inadequate evidence of the biological safety of water (7). Under certain circumstances pathogenic bacteria can be isolated from waters containing few coliform bacteria (1). In addition to coliform bacteria such as *Escherichia coli* and *Klebsiella pneumoniae* (4, 15), other opportunistic pathogens which have been used as indicators of water quality include *Pseudomonas aeruginosa* (2, 5), *Candida albicans* (3), and *Streptococcus faecalis* (1). Regardless of the indicator organisms used, such procedures determine only the probable presence of fecal pollution in water and give little or no information as to the identity of other pathogens which may be present.

The present study was undertaken to detect fecal pollution in selected Huntsville, Alabama streams and to identify the prevalent bacteria.

MATERIALS AND METHODS

Sampling stations were established along the principal streams in Huntsville at locations shown in Fig. 1. An initial survey was made by collecting water samples from sites 1-8 during the period from June 15 through September 15, 1976. A more detailed study was carried out at sites 9-12 along Aldridge Creek during the period from June 15, 1976 through May 15, 1977. Samples were taken from the respective collecting stations at weekly intervals. All samples were collected in sterile 250-ml glass bottles submerged 5-10 inches below the surface of the water and were immediately placed on ice. Bacteriological examinations were performed on the day of collection.

The most probable number (MPN) of total coliform bacteria contained in water samples from Aldridge Creek was determined by inoculating multiple tubes of phenol red lactose broth with serial dilutions of each water sample according to standard methods (1). Presumptive evidence for the presence of fecal streptococci was obtained by observing turbidity in tubes of sodium azide dextrose broth following inoculation with aliquots of water samples and subsequent incubation at 37° C for 48 hr (1). The

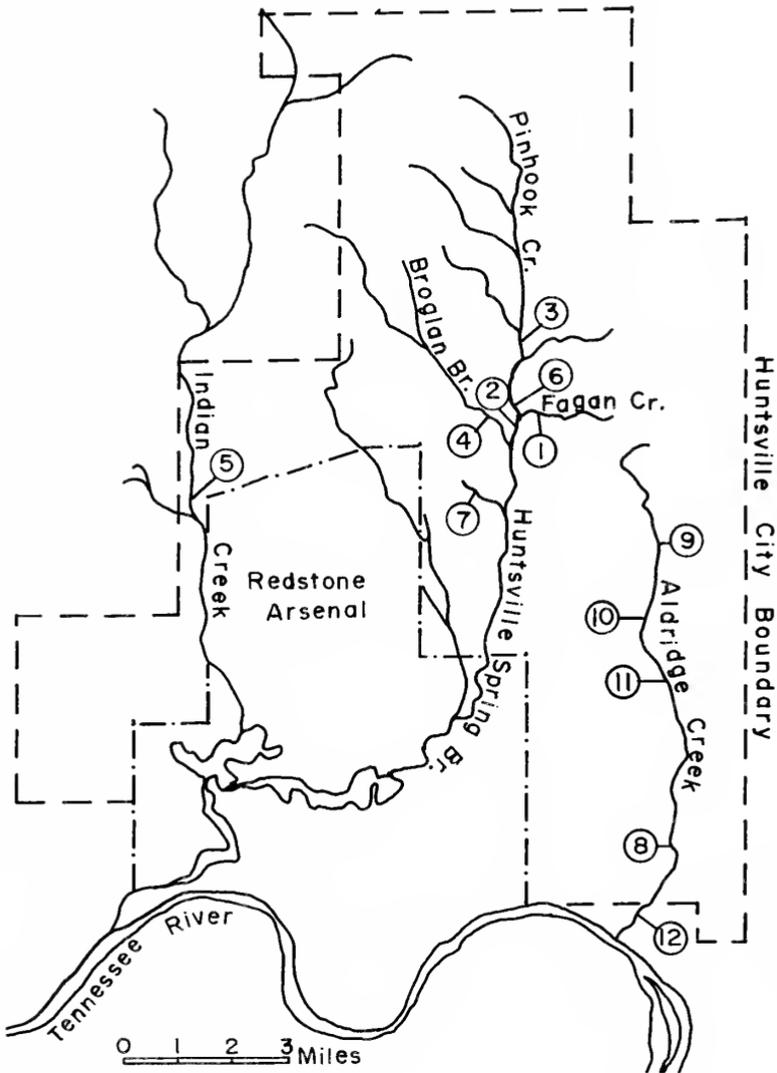


Fig. 1. Huntsville streams showing sampling stations. Stations are numbered as follows: 1. Fagan Creek above confluence with Huntsville Spring Branch; 2. Huntsville Spring Branch at Lagoon Exit; 3. Pinhook Creek at Traylor Island; 4. Brogplan Branch at Governors Drive; 5. Indian Creek at US Highway 20; 6. Big Spring at Fountain Pool; 7. Brahan Spring at North Lagoon; 8. Aldridge Creek, mile point 2.1; 9. Aldridge Creek, mile point 7.7; 10. Aldridge Creek, mile point 6.6; 11. Aldridge Creek, mile point 5.9; 12. Aldridge Creek, mile point 0.8.

Bacteriological Assessment of Aldridge Creek

presence of fecal streptococci was confirmed by observing growth in ethyl violet azide broth after transfer of growth from azide dextrose broth and further incubation at 37° C for 48 hr (1).

To enumerate total viable bacteria, tenfold serial dilutions of water samples were prepared in sterile distilled water, a 1-ml portion of each dilution was mixed with molten plate count agar, and the mixture was poured into sterile petri plates. The colonies which appeared after incubation of the plates at 37° C for 48 hr were counted with the aid of a colony counter (Model C110, New Brunswick Scientific Co., New Brunswick, N.J.). All media were obtained in dehydrated form from Difco, Detroit, Mich.

For isolation of Gram negative bacteria, 0.3 ml of each water sample were spread on the surface of eosin methylene blue agar. Following incubation of the plates for 24 hr at 37° C, colonies of representative organisms were transferred to nutrient agar slants and subsequently identified according to their reaction to oxidase reagent (p-aminodimethylaniline monohydrochloride) and by the API system (Analytab Products, Inc., Plainview, N.Y.).

All *Escherichia coli* isolates were tested for their ability to agglutinate in polyvalent and group-specific OK antisera (Lederle Diagnostics, Pearl River, N.Y.) in order to identify somatic and envelope antigens.

Data on average monthly temperatures and precipitation were obtained from The Johnson Environmental and Energy Center, University of Alabama in Huntsville.

RESULTS AND DISCUSSION

Collecting stations for the initial 3-month phase of the study were located within the city limits of Huntsville (Fig. 1, stations 1-8). These streams receive stormwaters primarily from residential and industrial areas. Bacteriological analyses of water samples collected during this phase were restricted to the identification of Gram negative bacilli isolated from the samples. The identities of the 23 bacterial species recovered from the various collecting stations are summarized in Table 1. *Enterobacter cloacae* and *Pseudomonas aeruginosa* were the most widely distributed organisms and were recovered from all collecting stations. *Aeromonas hydrophila*, *Citrobacter freundii*, *Enterobacter agglomerans*, and *Escherichia coli* also were widely distributed as indicated by the isolation of these species from 7 of the 8 collecting sites. *Klebsiella pneumoniae* was isolated from 6 stations. In addition to *E. coli* isolates which were not groupable when tested with specific antisera, stations 6 and 7 also yielded *E. coli* strains belonging to serogroups O26:K60, O111:K58, and O55:K59. Such serogroups are among those which are generally accepted as potential agents of diarrhea in infants and young children (8).

During this initial study enteric pathogens belonging to the genera *Salmonella*, *Shigella*, and *Vibrio* were not isolated from Huntsville

Table 1. Bacterial species recovered from Huntsville streams.^a

Species	Sampling stations ^b							
	1	2	3	4	5	6	7	8
<i>Acinetobacter calcoaceticus</i>	+ ^c	-	-	-	+	+	-	+
<i>Aeromonas hydrophila</i>	+	+	+	+	+	-	-	+
<i>Arizona hindshawii</i>	-	-	-	-	-	-	-	+
<i>Chromobacterium</i> sp.	+	-	-	-	-	-	-	-
<i>Citrobacter diversus</i>	-	-	-	+	-	-	-	+
<i>Citrobacter freundii</i>	-	+	+	+	+	+	+	+
<i>Enterobacter aerogenes</i>	-	+	-	+	-	+	+	-
<i>Enterobacter agglomerans</i>	+	+	+	+	+	-	+	+
<i>Enterobacter cloacae</i>	+	+	+	+	+	+	+	+
<i>Enterobacter hafnia</i>	-	+	-	-	-	-	-	-
<i>Escherichia coli</i> ^d	-	+	+	+	+	+	+	+
<i>Flavobacterium</i> sp.	-	-	+	+	-	+	-	+
<i>Klebsiella pneumoniae</i>	-	+	+	+	+	-	+	+
<i>Klebsiella ozaenae</i>	-	-	-	-	-	+	-	-
<i>Klebsiella rhinoschleromatis</i>	-	-	-	-	-	+	-	-
<i>Pseudomonas aeruginosa</i>	+	+	+	+	+	+	+	+
<i>Pseudomonas fluorescens</i>	+	+	-	+	-	-	-	-
<i>Pseudomonas maltophilia</i>	+	-	-	-	+	-	-	-
<i>Pseudomonas putrefaciens</i>	-	-	-	+	-	-	-	-
<i>Pseudomonas</i> sp.	-	-	+	-	-	+	+	+
<i>Serratia liquefaciens</i>	-	+	-	-	-	-	-	-
<i>Serratia marcescens</i>	-	+	+	-	+	-	-	-
<i>Yersinia enterocolitica</i>	-	-	-	-	-	-	+	-

^aComposite results from samples collected weekly during the period from June 15 through September 15, 1976.

^bLocations of sampling stations are shown in Fig. 1.

^c+ indicates presence, - indicates absence of isolate.

^dIncludes both antigenically groupable and nongroupable strains.

streams. However, enteropathogenic strains of *E. coli* and numerous opportunistic pathogens were isolated. Strains of *Citrobacter freundii*, *Arizona hindshawii*, and *Yersinia enterocolitica* all have been incriminated in occasional cases of gastroenteritis (8). Species of *Pseudomonas*, *Klebsiella*, and *Flavobacterium* have been associated with pathological conditions of the respiratory tract in susceptible individuals (13). *Pseudomonas aeruginosa* and *Aeromonas hydrophila* occasionally produce wound infections associated with aquatic injuries (2, 12, 16). Consequently, it seems reasonable to conclude that a potential public health hazard may be associated with waters from these streams.

Bacteriological Assessment of Aldridge Creek

A more extensive survey was made of the bacterial flora found in Aldridge Creek (Fig. 1, stations 9-12) throughout a one year period. Aldridge Creek presents a different ecological situation than other Huntsville streams. This creek lies within the watersheds of Huntsville Mountain, Garth Mountain, Green Mountain, and Monte Sano Mountain. No industries are located within its watershed and the creek receives runoff waters from the mountain slopes on either side of its banks and from several residential areas in the valleys. A farm containing beef cattle and approximately 1600 acres of pastureland is located at its upper end.

The MPN of total coliform bacilli and the fecal streptococcus index were determined on samples from station 10, a site located within a densely populated residential area. As shown in Table 2, the MPN of coliforms, total bacterial densities, and fecal streptococcus index were indicative of bacterial pollution throughout the year. However, these indices were generally highest during the warmer months and lowest during January when the average monthly temperature was below freezing. Fecal streptococci could not be detected during January and February, but presumptive and confirmed tests for these bacteria became positive when the average monthly temperature reached 55° F or above. The total bacterial count, which included some bacteria native to soil and aquatic environments as well as those indigenous to animals, was only 218/ml during January indicating the suppressive effects of cold temperatures on growth of many types of bacteria. Rainfall apparently had little influence on the presence or densities of fecal bacteria because there was no correlation between precipitation and the fecal indices.

Table 3 summarizes the identities of the Gram negative bacteria isolated throughout the year from stations 9, 10, 11, and 12 along Aldridge Creek. Although true pathogens were not recovered, a number of opportunistic pathogens were isolated (Table 3). Some of these opportunists showed seasonal variations in incidence of recovery. Species of *Enterobacter* were the most numerous isolates and were present at each site throughout the study period. However, *Enterobacter cloacae* was isolated in greatest numbers during August while more isolates of *E. agglomerans* were found during January than in warmer months. Species of *Serratia* were isolated most frequently during October and the highest incidence of *Klebsiella pneumoniae* occurred during October and November. *Yersinia enterocolitica*, another serious enteric opportunist, was recovered from station 10 during February; this organism is known to survive well in cold environments (11). Isolation of species of *Pseudomonas* did not follow any particular pattern and occurrence of these bacteria was noted at stations 9, 10, and 11 during each month of the study period. *Escherichia coli* occurred at all collecting stations during every month except April and May but the greatest incidence of these bacteria was found during October. *E. coli* serogroups O124:K72 and O125:K70 were isolated from station 9, O128:K67 and O55:K59 from station 10, and O127:K63 from station 11. All of these serogroups are among the enteropathogenic *E. coli* strains which have been incriminated in diarrheal disease (8).

Although a variety of opportunistic pathogens were isolated from Huntsville streams during this study the data do not provide an

Table 2. Coliform bacteria and fecal streptococci from Station 10 on Aldridge Creek.^a

Collection period	No. of coliforms ^b	CFU/ml ^c	Fecal streptococci ^d
6/76	>16,000	N.D. ^e	N.D.
7/76	>16,000	N.D.	N.D.
8/76	>16,000	N.D.	N.D.
9/76	>16,000	650,000	+
10/76	16,000	250,000	+
11/76	130	90,000	+
1/77	79	218	-
2/77	3,480	22,875	-
3/77	3,480	56,000	+
4/77	16,000	67,000	+
5/77	>16,000	78,000	+

^aResults are the average from 4 weekly collections during each month.

^bMost probable number observed per 100 ml.

^cColony forming units per ml.

^d+ indicates presence, - indicates absence of fecal streptococci determined as described (Materials and Methods).

^eNot determined.

indication as to the source of these organisms. Pollution of streams running through the older sections of the city may be due to surface runoff from industrial or residential sites or possibly to leakage from cracked sewers. A large number of bacterial species in Aldridge Creek may have been of non-fecal origin because the total viable bacterial count was much greater than the MPN of coliform bacteria (Table 2). In addition, many of the bacteria detected in Aldridge Creek may have been of animal origin and were washed into the creek from pastures. Excreta from farm animals grazing continuously during the test period provided a potential source of nutrients for the growth of many microorganisms residing in this creek as well as a possible source of *E. coli* and other enteric organisms. In future studies it may be useful to determine densities of fecal streptococci and the presence of *Streptococcus bovis* as well as densities of total coliform bacteria. Other investigators (10, 14) have suggested using the ratio of fecal coliforms to fecal streptococci to determine the origins of fecal pollution. Fecal streptococcus densities appear to be significantly higher than fecal coliform densities in feces of warm-blooded animals other than humans (2, 9). Furthermore, it has been shown that the presence of *S. bovis* as the predominant species in polluted water implicates farm animals as the

Bacteriological Assessment of Aldridge Creek

Table 3. Bacterial species recovered from Aldridge Creek.^a

Species	Sampling stations ^b			
	9	10	11	12
<i>Acinetobacter calcoaceticus</i>	- ^c	+	-	-
<i>Aeromonas hydrophila</i>	-	+	+	-
<i>Arizona hindshawi</i>	-	+	-	-
<i>Citrobacter diversus</i>	-	+	-	-
<i>Citrobacter freundii</i>	-	+	+	+
<i>Enterobacter aerogenes</i>	+	+	+	+
<i>Enterobacter agglomerans</i>	+	+	+	+
<i>Enterobacter cloacae</i>	+	+	+	+
<i>Enterobacter hafnia</i>	+	+	-	-
<i>Escherichia coli</i> ^d	+	+	+	+
<i>Flavobacterium</i> sp.	-	+	-	-
<i>Klebsiella pneumoniae</i>	+	+	+	+
<i>Proteus mirabilis</i>	-	+	-	-
<i>Proteus vulgaris</i>	-	+	-	-
<i>Pseudomonas aeruginosa</i>	+	+	-	-
<i>Pseudomonas maltophilia</i>	+	-	+	-
<i>Pseudomonas</i> sp.	+	+	+	-
<i>Serratia liquefaciens</i>	-	+	-	+
<i>Serratia marcescens</i>	+	+	+	+
<i>Serratia rubidea</i>	+	+	+	+
<i>Yersinia enterocolitica</i>	-	+	-	-

^aComposite of results from samples collected weekly during the period from June 15, 1976 through May 15, 1977.

^bLocations of sampling stations are shown in Fig. 1.

^c+ indicates presence, - indicates absence of isolate.

^dIncludes both antigenically groupable and nongroupable strains.

contaminating source (6). Regardless of the source of enteric bacteria isolated in the present studies, it can be concluded that the sanitary quality of water in Huntsville streams is unsatisfactory and periodic analysis of these streams for pathogenic bacteria is advisable since fecal pollution is present.

LITERATURE CITED

1. American Public Health Association. 1975. Standard methods for the examination of water and wastewater, 14th ed. American Public Health Association, New York.

2. Brodsky, M. H., and M. C. Nixon. 1973. Membrane filter method for the isolation and enumeration of *Pseudomonas aeruginosa* from swimming pools. *Appl. Microbiol.* 27:938-943.
3. Buck, J. D., and P. M. Bubocis. 1978. Membrane filter procedure for enumeration of *Candida albicans* in natural waters. *Appl. Environ. Microbiol.* 35:237-241.
4. Campbell, L. M., G. Michaels, R. Klein, and I. Roth. 1976. Isolation of *Klebsiella pneumoniae* from lake water. *Can. J. Microbiol.* 22:1762-1767.
5. Capelli, V. J., H. Kennedy, and M. A. Levin. 1976. *Pseudomonas aeruginosa*-fecal coliform relationships in estuarine and fresh recreational waters. *J. Water Pollut. Control Fed.* 48:367-376.
6. Doran, J. W., and D. M. Linn. 1979. Bacteriological quality of runoff water from pastureland. *Appl. Environ. Microbiol.* 37:985-991.
7. Dutka, B. J. 1973. Coliforms are an inadequate index of water quality. *J. Environ. Health* 36:39.
8. Ewing, W. H., and W. J. Martin. 1974. Enterobacteriaceae, p. 189-221. In E. H. Lennette, E. H. Spaulding, and J. P. Truant (ed.), *Manual of clinical microbiology*, 2nd ed. American Society for Microbiology, Washington, D.C.
9. Geldreich, E. E., and B. A. Kenner. 1969. Concepts of fecal streptococci in stream pollution. *J. Water Pollut. Control Fed.* 41:R336-352.
10. Geldreich, E. E. 1976. Fecal coliform and fecal streptococcus density relationships in waste discharges and receiving waters. *Crit. Rev. Environ. Control* 6:349-369.
11. Greenwood, J. R., S. M. Flanigan, and W. J. Martin. 1975. Clinical isolation of *Yersinia enterocolitica*: cold temperature enrichment. *J. Clin. Microbiol.* 2:559-560.
12. Hanson, F. G., J. Standridge, F. Jarrett, and D. G. Maki. 1977. Fresh water wound infection due to *Aeromonas hydrophila*. *J. Amer. Med. Assoc.* 238:1053-1054.
13. Isenberg, H. D., and B. G. Painter. 1974. Indigenous and pathogenic microorganisms of man, p. 45-58. In E. H. Lennette, E. H. Spaulding, and J. P. Truant (ed.), *Manual of clinical microbiology*, 2nd ed. American Society for Microbiology, Washington, D.C.
14. Lin, S., R. L. Evans, and D. B. Beuscher. 1974. Bacteriological assessment of Spoon River water quality. *Appl. Microbiol.* 28:288-297.

Bacteriological Assessment of Aldridge Creek

15. Matson, J. M., J. A. Spindler, and R. O. Blosser. 1974. Characterization of *Klebsiella* isolates from natural receiving waters and comparison with human isolates. *Appl. Microbiol.* 28:672-678.
16. Phillips, J. A., H. E. Bernhardt, and S. G. Rosenthal. 1974. *Aeromonas hydrophila* infections. *Pediatrics* 53:110-112.

CONCEPTS OF PRESENT SELF, IDEAL SELF, AND SELF IN FIVE YEARS
FOR FEMALE AND MALE STUDENTS IN INTRODUCTORY ANTHROPOLOGY¹

Avery G. Church
Department of Sociology and Anthropology
University of South Alabama
Mobile, AL 36688

Abstract. The research was concerned with differences between male and female students in introductory anthropology in a southern regional university in concepts of present self, ideal self, and self in five years. The null hypothesis was adopted regarding group differences. The semantic differential technique with 15 adjective pairs was used in measuring the above types of self concepts. Two of the most important findings were the significantly higher scores for the males on the hard-soft scale for all of the types of self concepts and the tendency for the females, although significantly in only two instances, to score higher than the males on a large majority of the scales for each type of self concept.

The research reported here examined differences between male and female students in introductory anthropology in a southern regional university in concepts of present self, ideal self, and self in five years. The investigator knows of no study using the above sexual groups that has examined all of the aforementioned variables, research especially important in American culture in our time where sexual equality is of great concern to much of the citizenry and studies of self concepts important to school counselors and others concerned with the psychological functioning of young men and women.

Carl Rogers (1951) wrote that the self structure or self concept may be conceptualized in the following way:

. . . as an organized configuration of perceptions of one's characteristics and abilities; the precepts and concepts of the self in relation to others and to the environment; the value qualities which are perceived as associated with experiences and objects; and goals and ideals which are perceived as having positive or negative valence [p. 136].

Using the above definition, present self concepts are defined as a person's self concepts now, ideal self concepts as the type of self concepts a person would like to have, and predicted self concepts as what a person thinks her or his self concepts will be at some future time.

¹Manuscript received 13 February 1980; accepted 5 September 1980.

Concepts of Self

On the bases of some recent studies which indicate rising ratings of their own abilities by women and improvements in societal attitudes toward women (*Society*, 1974; Stewart, 1978; Yankelovich, 1974) and the similarity of the students in the two samples in the investigator's research in academic classification (freshman, sophomore, etc.) and in the extent of extracurricular activities, the females are not anticipated to differ significantly from the males in the previously mentioned types of self concepts.²

METHODOLOGY

In December of 1979 the investigator administered a questionnaire to about ninety-eight per cent of the students in two typical day classes in introductory anthropology at the University of South Alabama, Mobile, Alabama; and the findings reported here come from that larger study. Twenty-four of the subjects are males and 19 are females. About eighty-six per cent of the students could be broadly classified as Anglo-Americans and a large majority of the remainder as Afro-Americans (mostly females). For the females 11 were freshmen, four were sophomores, and four were juniors at the time of the study. For the males, 14 were freshmen, four were sophomores, three were juniors, and three were seniors at the time of the research.

Since many universities, especially in the South, are similar in sexual and ethnic composition to the one in which the research was conducted and since the students in introductory anthropology in the investigator's research should not be expected to differ substantially from other students, especially freshmen and sophomores, the findings reported here should have generality beyond the subjects who participated in the research or other students in introductory anthropology at the institution in which the research was conducted. Since the measures used in the part of the total study reported here were used in previous research by the investigator (Church, 1976, 1977, 1978), comparisons with other educational and cultural groupings are made possible.

Concepts of the present self, ideal self, and self in five years were measured by using the semantic differential technique with appropriate instructions and self concepts to be rated and 15 adjective pairs. Each adjective pair was provided with a seven place scale with more positive traits indicated by higher ratings. The three self concepts used were "yourself," "the kind of person you would *like* to be," and "yourself as you think you will be in five years." The 15 adjective pairs used were "Fast-Slow," "Strong-Weak," "Happy-Sad," "Hard-Soft," "Good Looking-Ugly," "Rich-Poor," "Good-Bad," "Smart-Dumb," "Sober-Drunk," "Clean-Dirty," "Successful-Unsuccessful," "Independent-Dependent," "Comfortable-Uncomfortable," "Powerful-Powerless," and "Hopeful-Hopeless." These varied in directionality and in order for the above types of self concepts as in previous relevant research by the

²The males did not differ significantly statistically (.05 level, two-tailed test) from the females in either level of academic classification or in the extent of extracurricular activities.

Church

investigator (Church, 1977, 1978). Instructions, the first type of self concept, and the first 11 of the above adjective pairs were the same as those utilized in the Indian Education Project at the University of Colorado (Graves, Powers, & Michener, 1967). Other instructions, the other types of self concepts, and the remaining four adjective pairs were identical to those used in other relevant research by the investigator (Church, 1976, 1977, 1978). Below are listed the wordings from the questionnaire for the instructions pertaining to each type of self concept.

People are different in the ways they think about themselves. Below are pairs of words which are opposite in meaning. Please describe yourself by placing a check in one of the seven spaces along the line between the two words.

For example, if you feel you are a pretty talkative person, you might mark this:

TALKATIVE

--	--	--	--	--	--	--	--

 QUIET
Work rapidly. Don't skip any. Describe yourself as *you* ordinarily think about yourself.

Think about the kind of person you would like to be . . . for a moment. Place a check in one of the spaces along the line between the two words which best describes the kind of person you would *like* to be.

Think about yourself once more. Place a check in one of the spaces along the line which best describes yourself as you think you will be in five years.³

The semantic differential technique was developed to measure the connotative meanings or emotional associations of concepts rather than their explicit or denotative meanings (Osgod, Suci, & Tannenbaum, 1957). This technique has been used with success both cross-linguistically and cross-culturally (Maclay & Ware, 1961; Osgood et al., 1957). It is typically used in ways similar to its use in the research reported here with the concepts to be rated and adjective pairs selected according to appropriateness to the type of research to be conducted. In previous research by the investigator (Church, 1976, 1977, 1978) the use of the technique in comparisons of Anglo-American and Navaho students indicated many expected significant differences between the groups in self concepts and in ethnic stereotypes of the average Indian and of the average white man.

RESULTS

The number of female and male subjects for each measure of concepts of the present self, means, standard deviations, and differences between the sexual groups are presented in Table 1. An inspection of this Table indicated that the null hypothesis was upheld for most of the comparisons

³The investigator acknowledges appreciation to Ms. Karen J. Faulk for assistance in the computer processing of the data.

Table 1
Sexual Group Differences in Concepts of Present Self

Measure	Number of Subjects		Mean		SD		t-values Females vs. Males
	Females	Males	Females	Males	Females	Males	
	Fast-slow	18	24	4.83	5.00	1.04	
Strong-weak	18	24	5.56	5.13	1.20	1.08	1.22
Happy-sad	18	24	5.83	4.96	1.34	1.65	1.84
Hard-soft	18	24	3.28	4.33	1.57	1.05	-2.62*
Good looking-ugly	18	24	5.28	4.92	1.13	.83	1.20
Rich-poor	18	24	4.28	4.38	1.27	.92	-.29
Good-bad	18	24	5.78	5.58	1.06	1.06	.59
Smart-dumb	18	24	5.17	5.38	1.54	.92	-.51
Sober-drunk	18	24	6.00	5.08	1.61	1.59	1.84
Clean-dirty	18	24	6.44	6.21	1.46	.98	.63
Successful-unsuccessful	18	24	5.67	5.21	1.09	1.35	1.18
Independent-dependent	18	24	5.72	5.25	1.27	1.68	1.00
Comfortable-uncomfortable	18	24	5.72	5.25	1.13	1.73	1.01
Powerful-powerless	18	24	5.11	4.75	1.18	1.23	.96
Hopeful-hopeless	18	24	6.17	5.88	1.25	1.19	.77

* p \leq .05 (two-tailed test)

Church

between the sexual groups. Only one difference was significant at the .05 level. The males scored significantly higher on the hard-soft scale. The females, however, had higher scores than the males on 11 of the 15 scales.

The number of female and male subjects for each measure of concepts of the ideal self, means, standard deviations, and differences between the sexual groups are presented in Table 2. An examination of this Table showed that the null hypothesis was affirmed for most of the comparisons between the sexual groups. Only two differences were significant at the .05 level. The males scored significantly higher on the hard-soft scale and the females significantly higher on the clean-dirty scale. The females had higher scores than the males on 10 of the 15 scales.

The number of female and male subjects for each measure of concepts of the self in five years, means, standard deviations, and differences between the sexual groups are presented in Table 3. An inspection of this Table indicated that the null hypothesis was upheld for most of the comparisons between the sexual groups. Only two differences were significant at the .05 level. The females scored significantly higher on the strong-weak scale and the males significantly higher on the hard-soft scale. The females had higher scores than the males on 13 of the 15 scales.

DISCUSSION

Two of the most important findings in the research reported here were the significantly higher scores for the males on the hard-soft scale, the only scale on which they scored significantly higher than the females, for all of the various types of self concepts and the tendency for the females, although significantly in only two instances, to score higher than the males on a large majority of the scales for each type of self concept. The findings concerning the hard-soft scale for the various kinds of self concepts may indicate that the males, generally speaking, in harmony with some traditional notions about manliness, see themselves as having, desiring, and expecting to have in the near future more emotional toughness than the females and that the females, although not seeing themselves as having, desiring, and expecting to have in the near future as much emotional toughness as the males, do see themselves as having, desiring, and expecting to have in the near future inner emotional strength as strong as or stronger than the males. The ratings of the females on the strong-weak scale surpassed the males for all of the various kinds of self concepts but only significantly for the self in five years. There is also the possibility that the males and females differed somewhat in their interpretations of hardness and strongness with physical attributes being more prominent in the thinking of the males. The significantly higher ratings of the females on the clean-dirty scale for the ideal self probably reflects some traditional expectations for women concerning grooming and homemaking.

CONCLUSION

The analyses of the data for the two groups of subjects indicated that the females did not have, generally speaking, impaired concepts of

Table 2
Sexual Group Differences in Concepts of Ideal Self

Measure	Number of Subjects		Mean		SD		t-values	
	Females	Males	Females	Males	Females	Males	Females	Males
Fast-slow	17	24	6.12	6.13	1.11	1.12		-.02
Strong-weak	19	24	6.58	6.21	.51	.83		1.80
Happy-sad	17	24	6.88	6.75	.33	.53		.91
Hard-soft	17	24	2.65	4.42	1.41	1.32		-4.12*
Good looking-ugly	17	24	6.53	6.33	.72	1.01		.69
Rich-poor	17	24	6.35	6.13	.79	.99		.79
Good-bad	17	24	6.76	6.50	.56	.83		1.14
Smart-dumb	18	24	6.78	6.75	.43	.44		.20
Sober-drunk	17	24	6.12	5.38	1.17	1.69		1.57
Clean-dirty	17	24	7.00	6.38	.00	.92		2.78*
Successful-unsuccessful	18	24	6.83	6.83	.51	.48		.00
Independent-dependent	17	24	5.82	6.38	1.91	1.56		-1.02
Comfortable-uncomfortable	18	24	6.89	6.63	.32	.88		1.22
Powerful-powerless	18	24	6.22	6.29	1.52	.86		-1.17
Hopeful-hopeless	17	24	6.71	6.54	.59	.78		.73

* p < .05 (two-tailed test)

Table 3
Sexual Group Differences in Concepts of Self in 5 Years

Measure	Number of Subjects		Mean		SD		t-values	
	Females	Males	Females	Males	Females	Males	Females	Males
Fast-slow	19	24	5.53	5.67	.96	.87		-.50
Strong-weak	18	24	6.22	5.71	.73	.81		2.12*
Happy-sad	18	24	6.22	5.88	.94	1.12		1.06
Hard-soft	18	24	3.56	4.58	1.92	1.02		-2.07*
Good looking-ugly	18	24	5.61	5.42	1.15	.93		.61
Rich-poor	18	24	5.50	5.42	1.15	1.02		.25
Good-bad	18	24	6.17	5.88	.71	.90		1.14
Smart-dumb	18	24	6.39	6.00	.85	.83		1.48
Sober-drunk	18	24	6.22	5.42	1.17	1.41		1.97
Clean-dirty	18	24	6.67	6.29	.59	.91		1.52
Successful-unsuccessful	19	24	6.32	5.67	1.06	1.05		2.01
Independent-dependent	19	24	6.37	5.88	1.26	1.60		1.10
Comfortable-uncomfortable	18	24	6.06	5.58	1.16	1.41		1.15
Powerful-powerless	18	24	5.94	5.42	.80	1.02		1.82
Hopeful-hopeless	18	24	6.22	5.96	1.11	1.16		.74

* $p < .05$ (two-tailed test)

Concepts of Self

the present self, ideal self, and self in five years as compared with the males. With the exception of the scale of hard-soft for the three types of self concepts, there was a noticeable tendency for the females to surpass the males on a large majority of the scales for each type of self concept, although significantly in only two instances. The findings in the study add support to the contention that ratings by women of their own abilities are rising. As indicated previously, the findings in the research reported here should have generality beyond the specific students who participated in the study.

REFERENCES

- Church, A. G. Academic achievement, IQ, level of occupational plans, and ethnic stereotypes for Anglos and Navahos in a multi-ethnic high school. *The Southern Journal of Education Research*, 1976, X, 3, 184-201.
- Church, A. G. Academic achievement, IQ, level of occupational plans, and self-concepts for Anglo and Navaho high school students. *Psychology*, 1977, 14, 1, 24-40.
- Church, A. G. Personal control, delay of gratification, ethnic stereotypes, and self-concepts for Anglo and Navaho high school seniors. *Psychology, A Quarterly Journal of Human Behavior*, 1978, 15, 3, 30-42.
- Graves, T. D., Powers, J. F., & Michener, B. P. *Socio-cultural and psychological factors in American Indian high school classroom performance and post-graduation success: Theory and methodology*. (Indian Education Research Rep. No. 1) Boulder: University of Colorado, 1967.
- Maclay, H., & Ware, E. E. Cross-cultural use of the semantic differential. *Behavioral Science*, 1961, 6, 185-190.
- Osgood, C. E., Suci, G. J., & Tannenbaum, P. H. *The measurement of meaning*. Urbana: The University of Illinois Press, 1957.
- Rogers, C. R. *Client-oriented therapy*. Boston: Houghton-Mifflin, 1951.
- Society*. Working women, 1974, 11, 6, March-April.
- Stewart, E. W. *Sociology: The human science*. New York: McGraw-Hill, 1978.
- Yankelovich, D. *The new morality: A profile of American youth in the 70's*. New York: McGraw-Hill, 1974.

THE STATUS OF PUBLIC EMPLOYEE LABOR-MANAGEMENT
RELATIONS IN ALABAMA¹

George Munchus III
Department of Management
University of Alabama in Birmingham
Birmingham, AL 35294

INTRODUCTION

With the recent passage of comprehensive public employee bargaining laws in Florida, Iowa, and Montana [1], Alabama is still a state without comprehensive public employee labor relations legislation. For the past several years (1976 through 1979) the Alabama Labor Council, AFL-CIO has had introduced into the Alabama Legislature a bill that would "authorize collective bargaining by employees of the state and political subdivision, along with employees of non-profit institutions financially aided from public funds [2]." Thus far, neither bill has been reported out of the senate committee on Business & Labor. With Alabama being a leader (20%) as it relates to union growth and development in the private sector in so far as the southeastern states are concerned [3] there is considerable labor-management activity in the public sector. The purpose of this paper is to provide an exploratory analysis of the past, present, and future public sector labor-management relations developments for the State of Alabama.

The legal and legislative framework for collective bargaining will be discussed, as well as the extent of union organization and data on lost time (work stoppages) due to labor-management disputes. A cursory review of some public sector disputes, negotiations, and settlements will be reviewed. Based on this discussion a prognosis of future developments in this area will be made.

LEGAL FRAMEWORK

Jedel and Rutherford [4] in an excellent analysis of public sector labor relations in the southeast noted that Alabama was one of three southeastern states (Georgia and North Carolina are the others) where public employees were prohibited by legislation from joining a labor union. However, in 1972 the Circuit Court of Madison County (Alabama) decided the statute to be unconstitutional on the grounds it denied public employees their First Amendment right of freedom of association [5]. It is interesting to note that when the statute prohibiting public

¹Manuscript received 18 July 1980; accepted 8 September 1980.

Public Employee Labor-Management Relations

employees from joining a labor union, known as the "Solomon Act" [6] was adopted it exempted from its application employees of the state owned docks, Bryce Hospital, Searcy Hospital, Partlow School, and most public school teachers. The Alabama Labor Council v. Frazier (Circuit Court of Madison County) case was not appealed by the Attorney General, but he subsequently expressed his agreement with Madison County Circuit Judge Roy Mayhall in several letters to various public officials in the State of Alabama [7]. With the Solomon Act voided there is currently no visible statutory restriction on public employees joining labor organizations. Neither is there state protective legislation for public employees who may be discriminated against in their employment because of union activity other than First Amendment protection to sue directly in Federal Court under the Civil Rights Act of 1871, 42 U.S. (.§ 1938) [8]. Although, this may not completely protect public employees from arbitrary denial of their rights by some public employers, it does enable the public employee to freely join or not join a union. However, there is still no procedural mechanism for employee associations to gain exclusive recognition to bargain with their employing state unit or political subdivision.

There are however, two groups of Alabama public employees that have specific rights under state statute (Note Table 1), these being fire-fighters and public school teachers.

EXTENT OF UNION ORGANIZATION

Public employees in Alabama are not strangers to the national trend of labor unrest nor increased unionization among their own ranks. One area where data is difficult to obtain is the actual number of public employees who belong to unions (professional associations) that engage in collective bargaining for their respective members. The public service concept of a public employer to bargain appears to be more of a political issue rather than one governed by legal principles. Most of the data on union organizations (Table 2) in the public sector was obtained through secondary sources such as newspapers, labor publications, etc. When possible, union officials were contacted about membership strength. Most union officials appeared to have been interested in potential membership rather than current or actual membership. The Laborers International Union of North America, AFL-CIO (LIUNA, AFL-CIO) and the American Federation of State, County, and Municipal Employees, AFL-CIO (AFSCME, AFL-CIO) appear to be the most active in the state. However, the Alabama Education Association (NEA) and the state affiliate of the American Federation of Teachers, AFL-CIO also represent a sizable number of public school teachers and support (non-teaching) personnel. At one time the Alabama Brotherhood of Law Enforcement Employees (ABLE) was affiliated with three national unions, but the Laborers International Union of North America, AFL-CIO (LIUNA, AFL-CIO) rescinded their charter because a "number of police strikes were not sanctioned or approved by the national LIU" [9] according to the LIU international representative for Alabama.

TABLE 1
PUBLIC EMPLOYEE LABOR STATUTE COVERAGE IN ALABAMA

Firefighters	Public School Teachers
<p><i>Law</i></p> <ol style="list-style-type: none"> Sections 1 and 2, Title 37, Article 7, Section 450(3) as enacted by H.B. 146, L. 1967. Entitles firefighters to the right to present proposals regarding salaries and other conditions of employment. Employer is not required to bargain. 	<p><i>Law</i></p> <ol style="list-style-type: none"> Sections 73, 166, and 653, Title 52, Code of Alabama. Section 73 as amended by Act 1023, L. 1973; Section 166 as amended by Act 1022, L. 1973; Section 653 as enacted by Act 655, L. 1973. Provides for consultation with professional organizations of certified employees and dues deduction.
<p><i>Coverage</i></p> <p>All firefighters serving the state or any municipality in the state either as paid firemen or as volunteer firefighters (who comply with the provisions of this section).</p>	<p><i>Coverage</i></p> <p>Certified employees in any school district, county, and city.</p>
<p><i>Employee Rights</i></p> <ol style="list-style-type: none"> To join a labor union. To refrain from joining a union. 	<p><i>Employee Rules</i></p> <p>The county board of education shall determine policy for the county and prescribe rules and regulations for the conduct and management of the school for its employees.</p>
<p><i>Union Security</i></p> <p>Alabama has a right to work law prohibiting any employment conditional upon membership in a union.</p>	<p><i>Employee Representation</i></p> <p>The board of education shall consult with the employee organization representing the majority of employees.</p>

TABLE 1--Continued

Firefighters

Impasse Procedures

The governor may appoint a board of mediation consisting of three members:

- a. For the purpose of gathering facts and information and hearing evidence concerning the cause of any strike, lockout, or other dispute.
- b. For the purpose of making recommendations; and
- c. For the purpose of arbitrating such strike, lockout, or dispute if the parties involved submit the dispute for arbitration.

Unfair Labor Practices/Employer

1. Restrict employee's right to join a union.
2. Discriminate against union members.

Strike/Penalties

1. No firefighters may be a member of a union that asserts the right to strike, or participate in strikes.
2. Participation in a strike is punishable by a fine of not less than \$100 and not more than \$1,000 with possible imprisonment of up to 6 months.
3. Conspiring to participate in a strike is punishable by a fine of not more than \$500 and imprisonment of up to 3 months.

Source: *Labor Legislation in the Public Sector*, School of Public and Environmental Affairs, Indiana University, Bloomington, Indiana (June, 1979), pp. 1-2.

TABLE 2
UNIONS/PROFESSIONAL ASSOCIATIONS IN ALABAMA THAT HAVE PUBLIC EMPLOYEES AS MEMBERS

Union	Affiliate	Type Employee	Agency/Municipality Involved With
Alabama Brotherhood of Law Enforcement Employees (ABLE)	*LIU, AFL-CIO AFT, AFL-CIO AFSCME, AFL-CIO	Deputies Policemen	Jefferson County Tarrant City Fairfield Vestavia Hills Gardendale Irondale
Laborers International Union of North America (LIUNA)	AFL-CIO	Laborers Helpers	Water Works Board of Birmingham
Birmingham Association of City Employees (BACE)	None	Office Clerical	Birmingham
Firefighters Association (FFA)	International Association of Firefighters	Firefighters	Birmingham
Fraternal Order of Police	National FOP	Police	Birmingham
Laborers International Union of North America (LIUNA)	AFL-CIO	Laborers Unclassified Employees	Birmingham
Laborers International Union of North America (LIUNA)	AFL-CIO	Unknown	Mobile
Unknown	Unknown	Clerical Laborers	Talladega
Unknown	Unknown	Police Laborers	Tuscaloosa

TABLE 2--Continued

Union	Affiliate	Type Employee	Agency/Municipality Involved With
Alabama Brotherhood of Law Enforcement Employees (ABLE)	AFSCME, AFL-CIO	Police Firefighters Laborers	Sylacauga
ABLE	AFSCME, AFL-CIO	Police	Huntsville
ABLE	AFSCME, AFL-CIO	Police Firefighters	Florence
ABLE	AFSCME, AFL-CIO	Sheriffs Deputies	Lauderdale County
AFSCME	AFL-CIO	Road & Bridge Crew, Court-house Clerks	Lauderdale County
Public Employee Federation	AFT, AFL-CIO	Public Works	Jefferson County
LIUNA	AFL-CIO	Unclassified Workers	Fairfield
LIUNA	AFL-CIO	Unclassified Workers	Gardendale
Alabama State Employees Association	Unknown	Varies	Varies

Source: Various newspapers, labor publications, and conversations with union and public officials in the State of Alabama.

* LIU rescinded ABLE's charter in December, 1978.

Collective Negotiation and Work Stoppages

The work stoppages that have occurred primarily involve requests by the union for wage increases, dues checkoff, and recognition. Although under a current Alabama Supreme Court decision (*Nichols v. Bolding*) "a city cannot make binding contracts or be forced into negotiations although fire fighter's proposals may be considered in good faith and parties may enter into a written, nonbinding memorandum" [10]. In actuality this results in no more than a gentleman's agreement. If such agreement is breached by the public employer then the only remedy the union has is at the ballot box as it relates to elected public officials who agreed to the memorandum of understanding.

Although the *Nichols v. Bolding* case involved the interpretation of the firefighters statute it has been extended to other public employees in the state of Alabama such as policemen and other city employees [11], an example being when the FOP in Birmingham attempted to enforce a clause in their contract with the city over the city's reduction in pension contribution from 12% to 9%. No work stoppage occurred at that time over the pension reduction issue. However, there have been several work stoppages (Note Table 3) in the state during the past several years. The length of time varied between 3 and 60 days. It must be noted that all work stoppages are not included in Table 3, only those reported by major metropolitan newspapers. Those reported by major newspapers are significant because Alabama is traditionally an agricultural, rural, and very conservative state. Most of the work stoppages have occurred in geographic areas where private sector labor-management relations are prevalent. In most cases the striking employees were allowed to return to work, although in several cases they were terminated. Usually, when wages were an issue, some increase between what was offered and what was asked was given, although no pay was received while the employees were on strike. In almost all cases the request for dues checkoff and union recognition were denied. Only in Fairfield, Birmingham, Jefferson County, and Mobile do some employee groups have dues checkoff, recognition, and a meet and confer clause with municipal employers regarding traditional areas of human resource management.

PROGNOSIS OF FUTURE DEVELOPMENTS

As was stated at the outset, much additional data is needed in order to systematically evaluate the status of public sector labor relations in Alabama. However, it appears that the political process has frustrated the attempts of public employees to be represented by organizations of their choice. The spirit of collective bargaining has yet to become fully appreciated by either public employers or public unions in the absence of state legislation. While Alabama has no statutory law governing public employee collective bargaining except with firefighters, and that being limited to "non-binding" contracts, several principles have evolved in the area of case law before the courts (state and federal) relating to public employees. Alabama public employees enjoy First Amendment rights during their off-duty hours, they can be and have been terminated for engaging in strikes or work stoppages as "this does not infringe upon their First Amendment rights of association, free speech,

Public Employee Labor-Management Relations

TABLE 3

MUNICIPAL STRIKES IN ALABAMA: 1977-79

Date	Municipality	Length of Strike (Work Days)	Department	Major Issue(s)
August, 1977	Gardendale	4	Police Sanitation	Union Recognition Dues Checkoff
July, 1978	Cullman	8	Police	Dues Checkoff Union Recognition
October, 1978	Talladega	6	Sanitation Water & Sewer	Wage Increase
October, 1978	Sylacauga	10	Police Fire Sanitation	Union Recognition Dues Checkoff Promotion Test
October, 1978	Walker County	20	Courthouse Clerks Road & Bridge	Wage Increase
December, 1978	Huntsville	7	Police Fire Utility	Wage Increase Union Recognition
May, 1979	Birmingham	3	Police Fire Sanitation	Health Insurance Carrier
August, 1979	Water Works District of Birmingham	60	Water Workers Laborers	Union Recognition Wage Increase
December, 1979	Florence	5	Police	Union Recognition Wage Increase
December, 1979	Lauderdale County	6	Deputy Sheriffs Office Worker Radio Dis- patchers	Dues Checkoff Wage Increase

Source: *The Birmingham News* and other media sources.

or equal protection of the law" [12] stated U.S. District Court Judge J. Foy Guin of the Northern District of Alabama. Such decision was subsequently upheld by U.S. 5th Circuit Court of Appeals.

The public employer in Alabama has no statutory duty whatsoever to bargain in good faith, they may meet and confer, and even enter into a written memorandum of understanding although it is unenforceable in a

court of law. Public employees in Alabama clearly have the right to join or not join a labor organization. There is no right to grant dues check-off or formal recognition. It appears that the trend of informal recognition will continue to be cast into the political arena of city councils, county commissioner chambers, mayoral offices, etc. While this may appear to some to be the proper forum for all employee-employer matters, I am of the opinion that elected public officials will do what is politically expedient at the time. Usually this amounts to "crises bargaining" under the banner of what is in the interest of the various publics they serve. I do not propose any specific legislative scheme in this article, as this was done elsewhere [13]. However, if public policy decisions are to be made as they have been, there is a legislative need to remove, separate and define the issue of union representation and/or recognition and that of the union as a potential political advocate for elected public officials that are receptive to their request. Nonetheless, the stage is set in Alabama for an improved status of public employer-employee labor relations.

LITERATURE CITED

- [1] Hugh D. Jascourt, *Public Sector Labor Relations: Recent Trends and Developments* (Lexington, KY: The Council of State Governments, 1975), pp. 8-12.
- [2] House Bill 411, May 13, 1976, Alabama Legislature, pp. 1-14.
- [3] *Business Week*, "Labor's New Southern Strategy," (February 7, 1977), pp. 28-29.
- [4] Mike Jedel and William Rutherford, "Public Labor Relations in the Southeast," *Labor Law Journal* (August, 1974), pp. 483-495.
- [5] Alabama Labor Council v. Frazier, 81 LRRM 2155 (23rd Circuit No. 29375, June 15, 1972).
- [6] Code of Alabama, Title 55, Section 317(1) to 317(4).
- [7] Donald Davis, "Public Employee Collective Bargaining in Alabama," *The Alabama Lawyer* (October, 1977), p. 495.
- [8] American Federation of State, County, and Municipal Employees v. Bailey, 93 LRRM 2516, Civil Action No. 73-199 (N.D. Ala, 1973); Thomas v. Younglove, 545, F.2d1171; 93 LRRM 2558 (9th Circuit, 1976).
- [9] Bruce Carr, *The Birmingham News*, March 12, 1979.
- [10] Nichols v. Bolding (Alabama Supreme Court, 1973) 291 Alabama, 277 So. 2d 868 (1973).
- [11] Willis, et al. v. City of Birmingham (CV-77-503-250-WCB), Decided on January 23, 1978 in the Tenth Judicial Circuit of Alabama.

- [12] United Steelworkers of America v. University of Alabama in Birmingham, Civil Action No. 76-G-05-43-S (N.D. Alabama, March 25, 1977).
- [13] George Munchus III, "On a Negotiation Law in Alabama," *The Birmingham Post-Herald* (April 6, 1979), p. A4.

WRIGHT AUSTIN GARDNER¹

Emmett B. Carmichael
Professor Emeritus of Biochemistry
Medical Center
University of Alabama in Birmingham
Birmingham, AL 35213

Wright Austin Gardner was born on a farm in the Tyrone Community, Livingston County, Michigan, June 6, 1878. He was the son of Austin Wrightman and Julia Ella (Wright) Gardner. Young Wright Austin attended a one-room country school, which was about three miles from his home. Later, he graduated from the Fenton High School, Fenton, Michigan.

Young Gardner and his brother worked on the family farm after school, on Saturdays, and during the summer months. The Gardner family was deeply religious, only essential chores were done on Sundays. Reared in a devout Methodist home, Wright made plans to enter the Methodist Ministry by attending Albion College, Albion, Michigan, one of the oldest Methodist Colleges, having been established in 1835. While attending Albion, Mr. Gardner fell in love with a fellow student, Mabel Anna Anderson, and they were married on December 17, 1899. Wright earned the B.S. degree at Albion in 1902 (1).

Mr. Gardner's first position was Instructor of Mathematics, at Michigan State Agriculture College (now Michigan State University) Lansing, Michigan, 1902-1903 (2). The experience was so stimulating that he was determined to make teaching and research his two goals for the remainder of his life. With that decision, he entered graduate study at the University of Chicago during the summer of 1903. While at the University of Chicago, he was impressed by his association with Dr. Frank Rattray Lillie, the renowned zoologist, and next accepted an appointment (1903-1905) as Professor of Biology at Bradley University, Peoria, Illinois (3).

For the next several years Mr. Gardner taught biology at various institutions in Missouri, Oklahoma, and Wisconsin, while he continued to spend the summer vacation periods doing research at the University of Chicago and the University of Michigan, Ann Arbor. He taught both Botany and Zoology at the Missouri Valley College, Marshall, Missouri, during 1908-1909, where he also served on the Committee on Athletics (4).

After spending the 1910-1911 school term as Professor of Biology at Weatherford State Normal School, Weatherford, Oklahoma, he accepted a

¹Manuscript received 17 April 1980; accepted 26 August 1980.

Wright Austin Gardner

Professorship of Biology at the Northeastern State Normal School, Tahlequah, Oklahoma (now Northeastern Oklahoma State University) in 1911. As Professor of Biology, he taught courses in Physiology, Botany, Zoology, and Agriculture for five years. He served on several faculty committees, including Rules, Regulations, and Enrollment. He also served as Faculty Adviser to the Young Men's Christian Association, and helped direct the indoor baseball games (5).

While Mr. Gardner was conducting research at the University of Michigan, he was appointed a Whittier Fellow. Continuing his studies,



Wright Austin Gardner, 1878-1966

he was awarded the M.A. degree in 1915 (6). The following year (1916) the University of Chicago awarded him the Ph.D. degree, Cum Laude (7). Dr. Gardner's doctoral dissertation was entitled "The Effect of Light in the Germination of Seeds" (8). Following graduation, Dr. Gardner was appointed Associate Professor of Botany, The University of Idaho, Moscow, where he taught for the 1916-1917 school term (9).

In 1917, Dr. Gardner was appointed Professor of Botany and Plant Pathology at Alabama Polytechnic Institute (now Auburn University) Auburn, Alabama. The college and university administrations in Alabama were not research oriented during and following World War I, as evidenced by the number of publications by their science faculties. The principle emphasis seemed to be on teaching and applied technology. Actually most of the institutions only offered token support for basic research. Dr. Gardner appears to have been more motivated to research studies than many of his associates.

In an effort to stimulate the scientific community of Alabama, Dr. Gardner felt that it was both urgent and appropriate to organize a state wide Academy of Scientists. In order to promote such an organization, he began to write letters as "Acting Secretary" to the scientific leaders in both the teaching professions and the industrial community of Alabama during the early part of 1923. By August of 1923, he had received several favorable letters. However, Dr. Eugene A. Smith, State Geologist of Alabama, stated that although he approved of organizing the scientists in Alabama, a somewhat similar organization had been founded in 1891, and was called The Alabama Industrial and Scientific Society. He stated that the Society had originally held meetings in different cities of the State, but had finally settled on Birmingham as a permanent meeting site. The Society had been discontinued after about ten years because of small attendance at regular meetings (10).

Since Dr. Gardner had received so many favorable responses to his suggestion that an Academy of Scientists be organized, he wrote a general letter stating that he thought the best time for holding an organization meeting would be at the next regular annual meeting of the Alabama Educational Association in Montgomery, April 3-5, 1924. Dr. H. G. Dowling, Secretary of the Association, had assured Dr. Gardner of cooperation and recognition as a Section of the Alabama Educational Association.

The Alabama Academy of Science thus held its first meeting as the Science Section of the Alabama Educational Association at Sidney Lanier High School, Montgomery, Alabama, April 3-5, 1924, with Dr. Wright Austin Gardner as temporary Chairman (11, 12). Twenty-six scientific papers were presented during two sessions. At the close of the first session on Friday, April 4, 1924, the following officers were elected: President, Wright Austin Gardner, Alabama Polytechnic Institute; First Vice-President, H. D. Pallister, University of Alabama; Second Vice-President, Walter C. Jones, Birmingham-Southern College; Secretary-Treasurer, Sumner A. Ives, Howard College; and Honorary Dean, Dr. Eugene A. Smith, State Geologist. The Secretary reported that 36 Charter Members paid their annual dues.

The second Annual Meeting of the Alabama Academy of Science was held in the Scottish Rite Cathedral Building, Mobile, Alabama, April 3, 1925. Dr. Gardner presented a paper on "Decomposition of Chlorophyll." Fourteen other papers were presented at that meeting. The third Annual Meeting of the Academy was held at Phillips High School, Birmingham, Alabama, March 26-27, 1926, with 50 members and 8 visitors in attendance. Twenty-one papers were presented. Dr. Gardner retired as President of the Academy after having served in that office for the first three Annual Meetings. Dr. Stewart J. Lloyd, Department of Chemical Engineering, University of Alabama, was elected as the next President.

At the third Annual Meeting of the Academy in 1926, the desirability of making application for membership in the American Association for the Advancement of Science was discussed. Dr. Gardner was directed to make an application for Membership in the A.A.A.S. and the Permanent Secretary of the A.A.A.S. indicated that an application would receive consideration at a meeting on April 25, 1926. The application was approved and Dr. Gardner was elected the first Counselor to the A.A.A.S. (12).

The Academy continued to hold its Annual Meetings at Phillips High School for the next three years. At the Annual Meeting in 1929, the members voted to hold all future Annual Meetings at various Educational Institutions. It was thought that this would stimulate more state-wide interest in the sciences by the administrations of the institutions and their scientific faculties. In accordance with the new ruling, the Academy accepted an invitation from the Alabama Polytechnic Institute to hold the 1930 Annual Meeting on the Auburn campus. The meeting was held at A.P.I., with Dr. Fred Allison, Professor of Physics, as President.

Dr. Gardner continued to present papers at the Annual Meetings of the Academy, and he also took an active interest in the operation of the Academy until he retired as Professor of Botany and Plant Pathology, Alabama Polytechnic Institute, in 1931. The following papers, which Dr. Gardner presented at various Annual Meetings of the Academy, point up his broad scientific training and research interest: (1) Effect of Light on Germination of Light Sensitive Seeds; (2) Decomposition of Organic Toxins by Soil Organisms; (3) The Decomposition of Chlorophyll; (4) An Enzyme in the Rinds of Oranges; and (5) Black Resistance in Sweet Potatoes.

During research for his doctorate at the University of Chicago, Dr. Gardner had postulated that the chemical that induced the light effect on germination was an enzyme. Apparently he was aware that he had not revealed the entire story in his studies, but he never returned to the task. Later, Dr. Harry A. Borthwick and Associates, U.S. Department of Agriculture, Beltsville, Maryland, concerned themselves with the effect of light on the germination of lettuce seeds. After many years of study, they discovered and isolated the specific chemical that induced the light effects and named it phytochrome. Although Dr. Gardner did not isolate phytochrome, his postulates of its formation and nature were correct. Possibly his original reports may have stimulated Dr. Borthwick and his associates in their researches on the effect of light on germination (8).

One of Dr. Gardner's students summed up his forte in teaching as an innovator and motivator for the better than average student. He had the

ability and insight to identify promising undergraduate students and to challenge them and encourage them to attend graduate school in the appropriate plant science. A few such individuals stimulated by Dr. Gardner and who became recognized scientists are listed below: Dewey Stewart, B.S. degree, A.P.I., 1922; M.S. degree, Michigan State University, 1924; Pathologist and Agronomist, U.S. Department of Agriculture (13). Edwin V. Smith, B.S. degree, A.P.I., 1928, Dean and Director, School of Agriculture and Agricultural Experiment Station, Auburn University (14). Buford Horace Grigsby, B.S. degree, A.P.I., 1930; M.S. degree, Michigan State University, 1932; Ph.D. degree, 1937. Winston William Jones, B.S. degree, A.P.I., 1931; M.S. degree, Purdue University, 1933; Ph.D. degree, University of Chicago, 1936.

In addition to membership in the Alabama Academy of Science, Dr. Gardner enjoyed membership in several other professional societies. He helped found the American Society of Plant Physiologists, and served as its Secretary-Treasurer during 1925-1926, and 1930-1932, and as Vice-President from 1926-1927. He was a member of the A.A.A.S., the Botanical Society of America, and the American Phytopathological Society (15, 16). From a humble background, Wright Austin Gardner prepared himself to be a leader among scientists.

While living in Auburn, Dr. Gardner became active in several local organizations. He was a member of the Auburn Lions Club and the Opelika Commandry of Knight Templar, and served as Past High Priest of the Royal Arch Chapter. In 1920, Dr. Gardner was elected a member of Gamma Sigma Delta, the Honorary Society of Agriculture. He was a member of Phi Kappa Phi, the General Honor Society that encourages superior scholarship (17).

After Dr. Gardner retired, he took over the local Pineview Dairy that had been operated by two of his sons, Harmon and Louis. It was a small jersey dairy that had been a project for the sons to earn money to help pay their way through A.P.I. In 1932, Dr. Gardner purchased land on the outskirts of Auburn and the herd was enlarged. Records were kept on milk production by each cow and several of them earned the prestigious "Ton of Gold Award." The milk was sold to the University Creamery and to the Carnation Milk Company.

The Gardners were the parents of four children, and they supervised the childrens' education to prepare them to be useful citizens. Since the family moved from city to city, the childrens' educational experiences were somewhat similar to those experienced by children of military personnel. However, all four of the Gardner children graduated at Auburn High School and enrolled at the Alabama Polytechnic Institute. Harmon Austin was born at Lansing, Michigan, on February 4, 1903. He earned the B.S. degree in Agriculture (with Highest Honors) at A.P.I. in 1922, and the M.S. degree in Poultry Husbandry at Rutgers University in 1924. He served as Poultry Inspector for the Alabama Department of Agriculture and Industry and then operated his own hatchery. Louis Wright was born at Peoria, Illinois on May 1, 1904. He earned the B.S. degree in Electrical Engineering (with Distinction) at A.P.I. in 1923, and the M.S. degree in Physics, University of California, Berkley in 1928. He served as Senior

Scientist and Director of the Gulf Research and Development Company (Gulf Oil Company). Mabel Grace was born at Hartford, Michigan on July 16, 1905. She earned the B.S. degree in Home Economics (with Highest Honors) at A.P.I. in 1926. She later graduated from the Merrill Palmer School and Childrens Hospital, Detroit, Michigan, and served as an Instructor in the School of Nursing, Cornell University, Ithaca, N.Y. and at the University of Tennessee, Knoxville. She later served as Assistant Professor of Home Economics at A.P.I. from 1932-1935, where she had charge of the Child Development Program and the Nursery School. Donald Anderson was born at Superior, Wisconsin on July 3, 1906. He earned the B.S. degree in Mechanical Engineering at A.P.I. in 1929. He retired as Chief of Operations, U.S. Corps of Engineers, Wilmington, North Carolina in 1959 (17, 18).

Mrs. Gardner died June 10, 1962 and Dr. Gardner on May 31, 1966. Both Dr. and Mrs. Gardner were interred in the Pine Hill Cemetery, Auburn, Alabama (19, 20, 21, 22, 23).

REFERENCES

1. Private communication, President Bernard T. Lomas, Albion College, Albion, Michigan.
2. Catalogue, Michigan Agriculture College, Lansing, Michigan, 1902, page 8.
3. Yearbook, Bradley University, Peoria, Illinois, 1905, page 140.
4. Bulletin, Missouri Valley College, Marshall, Missouri, 1909, pages 6-7 and 58-61.
5. Private communication, Helen Wheat, Librarian, Northeastern Oklahoma State University, Tahlequah, Oklahoma.
6. Private communication, Professor Michael J. Wayne, University of Michigan, Ann Arbor.
7. Private communication, Jonathan Kleinhard, Assistant to the President, University of Chicago.
8. Gardner, Wright A.: Effect of Light on Germination of Light-Sensitive Seeds. *The Botanical Gazette*, 71:249-288, April, 1921.
9. Private communication, Sylvia Schoepflin, Assistant to the President, University of Idaho, Moscow.
10. Owen, Thomas McAdory. *The Alabama Industrial and Scientific Society, History of Alabama and Dictionary of Alabama Biography*, 2:776-777, 1921.
11. *The Organization of the Alabama Academy of Science*. *J. Ala. Acad. Sci.* 3:7-11, 1932.

12. Minutes of the first two meetings of the Alabama Academy of Science, J. Ala. Acad. Sci. 4:38-43, 1933.
13. Private communication, Dewey Stewart, U.S. Dept. of Agriculture.
14. Private communication, Dean E. V. Smith, Auburn University. Auburn, Alabama.
15. Biographical sketch of Dr. Gardner. Who's Who in America, 17th Edition, page 1912, 1932-1933.
16. Biographical sketch of Dr. Gardner. American Men of Science, 10th Edition, page 1344, 1960.
17. Private communications with Dr. Gardner's children.
18. Private communications with Mrs. Doris B. Gardner, Dr. Gardner's granddaughter-in-law.
19. Private communication, Tom A. Stallworth, Registrar, Auburn University, Auburn, Alabama.
20. Science Academy to Honor Founder, Dr. W. A. Gardner, The Birmingham News, March 3, 1964.
21. As Founder of Science Academy, Auburn University to Honor Dr. Gardner, Birmingham Post-Herald, April 3, 1964.
22. Funeral Friday for Dr. Gardner, Lee County Bulletin, June 2, 1966.
23. Dr. W. A. Gardner dies Tuesday. Funeral Friday. Opelika-Auburn News, June 3, 1966.

INDEX

Acceleration information, a time-to-go algorithm using	240
Adapa, S. R.	232
Adenosine monophosphate (cAMP), a research cycle--'3'5'	228
Adolescent behavior, the influence of self-concept on	229
Adriamycin: its effect on double minute chromosomes in the breast tumor cell line SW-613	194
Adrian, John L., Jr.	152
Agribusiness, north Alabama	209
Alabama city government, the impact of structure on executive power in an: the Auburn experience	215
Albright, C. W.	176
Alford, W. L.	207
Allen, Douglas S.	45
Anderson, F. Ruth	198
Anthropology, concepts of present self, ideal self, and self in five years for female and male students in intro- ductory	290
Antibiotic substance in yogurt, an	197
Aortic atherosclerosis in the Alabama wild turkey, occurrences of	182
Askew, Raymond F.	79
Asymmetric tonic neck reflex and muscle vibration on wrist extension strength in normal adults, effects of the	230
Atkinson, W. J.	207
Atwood, Jerry L.	195, 196, 196, 198, 199, 200, 201
Audio biofeedback and level of stress during labor	236
Bacteriological assessment of Aldridge Creek and other Huntsville, Alabama streams	280
Bailey, Earl J.	105
Baker, David C.	197, 198
Ball, Mary U.	193
Baugh, Charles M.	235
Beaton, John M.	236
Becker, Gerald L.	230
Behavioral studies of the teleost <i>Fundulus grandis</i>	183
Bertsch, W.	197
Binuclear copper complexes as catalysts for the air oxidation of O-diphenols	199
Biochemical transfer, via whole brain homogenate, of an acquired operant task in the rat, the	236
Bioheat transfer equations related to hyperthermia for tumor therapy, solutions of the	208
Biomass energy sources for Alabama	86
Black, Eric	177, 177
Bodden, Martin K.	223
Bolden, S. L.	182
Bolus, David	199

Index

Booker, O. J.	184
Boots, Larry R.	227, 234
Bradley, J. T.	179, 180, 181, 185, 186
Brain-ovary interactions in the house cricket	179
Brauerman, Ellie	235
Bridger, William M.	222
Bridges, R. R.	188
Britt, Sylvia Squires	236
Brown, James S., Jr.	215
Brown, Kathleen C.	228
Brown, Steve L.	191
Brunssen, Susan	234
Bryan, Stephen R.	222
Buckner, Ellen B.	234
Bugg, Charles E.	192
Calmodulin localization in mammalian spermatozoa	233
Cameron, Gregory	218
Campbell, P. S.	176, 176, 188
Canada, Larry C.	196
Carcharinidae, the reproductive system of one species of the Family	184
Carmichael, Emmett B.	192, 308
Carrroll, Chester C.	61
Carter, William A.	213
Catalytic copper amines, an investigation of their active sites	200
Caudle, Anita	223
Caveat emptor: advertising patent medicines in Huntsville and Madison County	216
Cayman Brac: a field study in demarcation	205
Centronuclear (myotubular) myopathy--report of a kindred	223
Chadbourne, Phillip	206
Chandra, D. V. Satish	242
Chang, H. C.	180
Chao, Shoa-Hua	207
Chronister, R. B.	237
Church, Avery G.	290
Circannual plasma T ₄ titers in the lizard <i>Cnemidophorus</i> <i>sexlineatus</i>	189
Clark, Junius M.	191, 221, 222
Clathrate systems involving TlSCN and aluminum alkyls, new liquid	196
Clelland, Jo A.	230
Cline, George B.	177, 177, 178, 178, 187
Close, David K.	190
<i>Cnemidophorus sexlineatus</i> during hibernation, aspects of the natural history of	182
Coal bluff bed lignites from Alabama, characterization of	203
Coal-mining production cost, effect of topsoiling on Alabama- area bituminous	105
Coals, moisture variability in Alabama: some economic problems	201
Coal, the role of, in our energy future	68

Index

Coleman, C. C.	227
Communicating through phrases and gestures	212
Cooper, William E., Jr.	16, 256, 273
Cormier, Milton J.	233
Corn mesophyll protoplasts in plant virus research, use of	181
Corticosterone binding activity in adrenal incubation media	185
Crockett, Philip A.	181
Crystal and molecular structure of bromofluoroacetic acid, a chiral hydrogen bonded dimer, the	199
Crystal structure of $(\eta^5\text{-C}_5\text{H}_4\text{SiMe}_3)_2\text{Zn}(\text{Cl})\text{CH}_2\text{C}_6\text{Me}_5$, the	198
Crystallographic studies of pisum satvum agglutinin	192
Cuprozinc superoxide dismutase in livers of aging rats, properties of	226
Curl, E. A.	191
Current, William L.	183, 184, 184
Curry, Ellen L.	230
Cusic, Anne Moreland	218
Cytotoxicity in the hamster, natural cell-mediated	224
Dachshunds, average inbreeding coefficients in registered	193
Dagg, C. P.	218, 218, 220
Dalton, M. Susan	199
Daniel, Kathryn Barchard	232
Davidson, Nita	232
Davis, William B.	224
Dawson, Steve	187
DeFrance, J. F.	237
Denine E. Paul	218
De Vall, Wilbur B.	203, 212
Diabetes mouse, effects of central 6-hydroxydopamine lesions on body weight and behavior in the	219
Diffuse interstellar bands, production of candidates for the	208
Disease, is degeneration of advanced years separable from	229
Donahue, Mark A.	227
<i>Donax dorotheae</i> and <i>Donax roemeri</i> , growth and mortality of	194
Double minute chromosomes in the breast tumor cell line SW-613, the effect of flask density on	195
Drug use, abuse and control	164
Dudley, Alden W., Jr.	222, 223
Dudley, early life of Robert, 1532-1564	214
Dudley, Mary A.	222
Dusi, Julian L.	45
Eaves, Richard Glen	213
Eduok, Etim	200
<i>Eimeria tuskegensis</i> in the cotton rat: actively induced resistance	184
<i>Eimeria tuskegensis</i> in the cotton rat, endogenous stages of	183
Electricity, the demand for, by widows and retired persons in Alabama: an income segmented approach	1
Elixon, Joseph	217
Embryonic gonads, development of cultured and transplanted	218
Emerson, Geraldine M.	228, 229
Energy and Alabama: 1980 annual meeting special symposium	61
Energy and economics	97

Index

Energy: Need vs demand	92
Ernst, John V.	183
Estradiol and progesterone action on rat uterine coenzyme levels	227
Estrogen-receptor complex, studies on the nuclear translocation of	176
Estrogen reversal of viablastine induced microtubular paracrystals	188
Estrogens with the equivalent receptor association constants do not always produce equivalent uterine responses even at equivalent dosage	176
Evans, Zoe A.	191, 221, 222, 280
Exercise, expectations of rewards and costs for	228
Falcon force: a new aerospace science program	212
Farm households, persistence of: Alabama, 1850 to 1860	216
Farmers, information needs and sources of Alabama	131
Film, the production of a laboratory safety	195
Fite, William H.	227
Fleming, Glenda	201
Flexible structures, active control of	240
Folic acid and aminopterin, a novel synthesis of	232
Folypolyglutamates, observations on the biosynthesis of	235
Forestry study committee, Alabama's legislative	203
Free, W. Joe	209, 210, 210
Friedrich, Joyce	197
Frith, Herb	178
Fungi of Alabama. IX. dematiaceous hypomycetes	30
Galapagos spreading center, east Pacific ocean, low temperature alteration of ferrobasalts from the	202
Ganjam, V. K.	189
Gant, Fred Allen	195
Gardner, Wright Austin	192, 308
Garthright, C. Lynn	256
Gastaldo, Robert A.	189
Gastric mucosa, the action of DIDS on the <i>in vitro</i>	234
Gaubatz, Jim W.	233
Gel electrophoresis of sonicated virons of two nuclear polyhedrosis viruses	249
Ghai, Rajendra D.	226
Giles, H. D.	220
Gilligan, Kay E.	182, 189
Goodling, J. S.	62
Graf, Edward R.	242
Gray, Wayne L.	224
Greeley, Leigh G.	223
Greeley, Mark S.	187
Gudauskas, R. T.	181, 181, 249
Guernsey, David L.	179
Hammer, Mildred L.	238
Hanvey, J.	197
Hardy, William E., Jr.	260
Harmon, Alan	208
Harper, James D.	249

Index

Harper, W. L.	20, 186
Harrison, George L.	131
Harrison, Robert	238
Harrison, S. D., Jr.	218
Hassell, James E.	223
Hawkins, L. D.	197, 198
Hayhurst, Don E.	215
Health education campaign, the evaluation of a	226
Heath, H.	197
Hemolymph of the slipper lobster (<i>Scyllarides nodifer</i>), chemical composition and cells of the	178
Henderson, C. M.	229
Henderson, H. A.	209
Herbert, Donald E., Jr.	220
Heteroatom cyclophane complexes of $-Cr(CO)_3$, preparation and structure of	201
Heteroatomic dienophiles to levopimaric acid, the addition of . .	197
Himmler, Frank N.	206
Hines, G. S.	47
Histamine: source and function in nucleus accumbens	237
Histidine decarboxylase, active-site-directed alkylations of . .	225
Hoggarth, Michael A.	179
Hool, J. N.	47
Hudson, Glenn	217
Hudson, Lois	186
Huebner, A.	181
Hunter, William E.	198
Hurst, J. R.	204
Hutton, B. S.	229
Hydrologic events and nutrient input to an Alabama stream	178
Hypertension, implications of tryptamine in	238
Indomethacin on teratogenicity of retinoic acid, influence of . .	218
Inman, Henry	216
Ion regulation by the gill membranes of the striped mullet (<i>Mugil cephalus</i>) as measured by perfusion studies	177
Irby, Don	1
Isoenzymes of phosphoglucomutase by fluorespectrophotometric assay of isoelectric focused muscle extracts of the slipper lobster (<i>Scyllarides nodifer</i>), detection and distribution of	178
James I and the protestant cause in France and Germany	214
Jarrell, Rember B.	198
Jewish people in Birmingham, a short history of	217
Jewish situation in Russia, 1870-75, Eugene Schuyler on the	215
Johnson, W. F.	20
Jolly, Alexander C.	241
Jones, Harold P.	233
Keating, Mark E.	224
Kerr, C. Reid	196
Keys, Charles E.	175
Kispert, Lowell D.	199
Krishnamurthy, N.	239
Krista, L. M.	182

Index

LaCour, Fritz A., Jr.	223
Lacy, A. Wayne	1
Lane, Roger S.	225, 226
Lange, Frances	231
Lasco, John à: a Polish religious reformer in England, 1550-1553	213
Lausch, Robert N.	224
Ledet, Michael T.	195
Lenz, Richard W.	233
Leonard, Maceo	209
Lesions of the noradrenergic bundle of the raphe nuclei on conditioned taste aversions in the rat, effects of	219
Limnology, the physiochemical, of a temporary pond in north Alabama	119
Lorden, Joan F.	219, 223
Loveless, G. C.	176
Lymphoid tissue, the effects of systemic candidiasis on	221
MacGregor, Robert, III	183, 187
Machuzak, Richard J.	242
Macrophages in resistance to herpes simplex virus type-1 infection, the role of	224
Male reproductive cycle of <i>Sternotherus minor depressus</i> , the	190
Management audit, the: a tool for measuring performance in aglime retailing	210
Marion, Ken R.	190, 190
Marker enzyme activities of cell components of gill tissue of the striped mullet (<i>Mugil cephalus</i>) following fractionation and purification in sucrose density gradients	177
Marks, Henry S.	217
Marks, Marsha K.	216
Marple, D. N.	20, 185, 186
Mathews, Sherrie Soustek	206
McCord, Joe M.	231
McDaniel, G. R.	182
McDuffy, James	192
McKnight, Robert H.	226, 227
McLaughlin, Ellen W.	185
McPherson, Roger J.	190
Meehan, Edward J., Jr.	192
<i>Mein Kampf</i> and the American courts	217
Microwaves, simple doppler effect experiment with	206
Minutes	243
Misiolek, Walter	105
Missile simulations, the use of continuous system simulation languages in realtime	241
Modlin, Richard F.	119, 179
Moore, Jayma A.	184
Moore, Karen	198
Morgan-Jones, G.	30
Morris, Philip E.	236
Morrissey, Kevin M.	194
Mullen, Michael	179
Munchus, George, III	211, 298

Index

Murdock, Marianne	226, 227
<i>Myxobolus</i> sp. (Myxosporida) in the largemouth bass, ultrastructure of	184
Na ⁺ K ⁺ -activated adenosine triphosphatase, cytochrome oxidase and glucose-6-phosphatase from gradient purified gill tissue of the blue crab (<i>Callinectes sapidus</i>), location of	187
Nair, M. G.	232
Neilson, Michael J.	201
Nemalinosiis--a fatal myopathy	222
Neonatal monosodium glutamate treatment on the feeding behavior of the mouse, effects of	223
Neutrophils, a plasma superoxide-dependent chemotactic factor for human	231
Newman, G. A.	176
Nicolaro, M. L.	180
Noise stress and corticoid binding in adrenal incubation media	186
Noise stress, interaction of, with adrenocortical responsive- ness to <i>in vivo</i> and <i>in vitro</i> ACTH stimulation	20
Nuclear fission: risk vs need	79
Nunan, Adrienne	201
Nunn, William B.	219
Nursing clinic--alternative for health care of the aged, a	238
Nursing research development, University of Alabama school of . .	232
Objective credit scoring--an analysis of agricultural borrower characteristics	260
<i>Obovaria unicolor</i> Lea from <i>Obovaria jacksoniana</i> Frierson, variation in the characteristics used to distinguish	179
Ocak, A.	197
Ofoten syncline, northern Norway, structural geology of the . . .	202
Oncology, extreme value theory of volume effect in radiation . .	220
Oogenesis in the banded sculpin, <i>Cottus caroliniae</i>	175
Optimal linear map for pattern recognition, an	242
Organic mercury, development of snail embryos treated with . . .	185
Ovary-fat body interactions in the house cricket	180
Paddock, Gary V.	233
Pagel, Patricia McKee	183
Pajares, Raoul, III	198
Palevitz, Barry	233
Panasonic personal and environmental dosimeters, response of . .	217
Paramagnetic resonance studies of alkaline earth oxides	206
Parker, J.	197
Parkman, Leslie C.	194, 195
Passerini, Edward	92
Pastrick, Harold L.	239
Pelleymounter, Mary A.	219
Pentadiene complexes, stable transition metal	200
Petrone, William F.	231
Phokachaipatana, S. E.	242
Pittman, Charles U., Jr.	200
Platt, Telse A.	280
Plott, W. E.	206

Index

Pluton from the Dadeville complex, Tallapoosa, County, Alabama, a metamorphosed mafic-ultramafic	201
Poirier, Gary R.	186
Port of Mobile on the Alabama economy, impact of the	204
Power logistic population growth	273
Power plant recirculation and entrainment impact: a solution for constant recirculation and once-through mortality rates	16
Prairie vole (<i>Microtus ochrogaster</i>), additional distributional records of the, from northern Alabama	45
Precocene treatment in the cricket (<i>Acheta domesticus</i>), metabolic effects of	181
Prediction of success on professional licensure examinations	227
Priester, Ralph D.	200
Prince, Hyacinth K.	185
Pritchett, J. F.	20, 185, 186, 188, 189
Prolactin response variation during initiation of lactation	234
Proteinase inhibitors in the male reproductive tract of mice	186
Public employee labor-management relations in Alabama, the status of	298
Public sector employee-employer relations in Alabama	211
Radar target modelling techniques	242
Ragland, Isabel M.	188
Rahimian, Fahimeh	191
Ratliff, Normal B., Jr.	222
Recombinant cDNA construction, improved methods for	233
Regan, Gerald T.	193, 194
Reproduction in fish: is 5-dihydrotestosterone involved?	187
Research to design in steel bolted connections, from	239
Research, development and acquisition investment strategy	239
Response surface, determination of distance to be moved from experiment to experiment when exploring a	47
Retail sales in CBD's of selected Alabama cities, pattern of decline in	205
Rhizosphere effect of herbicide-stressed sicklepod (<i>Cassia obtusifolia</i>) on <i>Fusarium oxysporum</i> F. sp. <i>vasinfectum</i>	191
Riggs, Lloyd S.	241
Riggsby, Dutchie S.	212
Riggsby, Ernest D.	212
Roberts, Janice W.	220
Rogers, Robin D.	196
Rosa, Edward	184
Rural clinic, the role of the nurse consultant in developing a	231
Rural landscape, the future of the: preservation or anonymity?	211
Rural real estate markets in major agricultural areas in Alabama	152
Sass, Edward A.	221
Sax, Steven R.	209
Scanning electron microscopy in dermatopathology	237
<i>Seeloporos undulatus</i> : variability and refractoriness to ovarian steroids, lateral orange coloration in female	256

Index

Schlefer, Ellen	175
Schmale, D. Maynard	241
Schrader, Ed L.	202
Scottish farming, early: a study in retardation	213
Sellers, Jeffrey C.	182, 189
Seltzer, S. M.	240
Settine, R. L.	197, 197
Shadinger, J. T., Jr.	205
Shakir, Riz	195, 196, 201
Shaner, Jim	175
Shaw, Brenda J.	223
Shoemaker, Richard L.	177, 234
Shotts, Reynold Q.	201, 203
Sign/logarithmic fast fourier transform, on implementing the	242
Siler, William	183
Simpson, T. A.	179
Singh, Shiva P.	249
Singularity expansion method analysis of two finite length thin cylinders of arbitrary orientation	241
Skinner, David G.	205
Solar energy: can we use it now?	62
Soybean mosaic virus, serum specific electron microscopy of	181
Stallings, James L.	131, 204
Stamps, Ricky	201
Starks, Scott A.	242, 242
Steinbeck, Klas	86
Steltenpohl, Mark G.	202
<i>Sternotherus odoratus</i> in north Alabama, seasonal spermatogenesis in	190
Strawn, H. B.	204
Street, Donald R.	1, 97
Streptococcal infection in the mouse, chronic	222
Subcellular organelles, regulation of free CA^{2+} levels by	230
Suddath, F. L.	192
Surf clam, <i>Donax dorotheae</i> , density and age structure of the	193
Swann, P.	197
Synthesis and chemistry of (R)- and (S)-2-benzyloxypropanal, the	198
Synthesis of 2-azido- and 3,6-diazido-10-methyl-acridinium bromides, the	197
Synthesis of new binuclear copper (II) complexes	198
Temperature acclimation in a hibernator, an adaptive strategy?	188
Temperature trends in Florence, Alabama, 1920-1977	206
Teratogenesis after co-administration of urethane and caffeine	220
Thermocouples, determination of thermal equilibrium times of	207
Three-body problem, a new set of integral equations for the	207
Till, M. L.	20, 185, 186
Tocus, Edward C.	164
Tohver, H. T.	206, 206
Treefrogs, introgressing: an acoustical-morphological study	175
Twiggs, Jeanne M.	214

Index

Ultrastructure and histochemistry of ducts in the albumen gland of the apple snail, <i>Pomacea paludosa</i>	235
Urban agriculture: presence, potentials, and problems	209
Urban speculation in the Tombigee Valley before the Civil War	205
$^{51}\text{V}(\text{n},\alpha)^{48}\text{Sc}$ and $^{54}\text{Fe}(\text{n},2\text{n})^{53}\text{Fe}$ reactions at 14.2 MeV, the	207
<i>Valvisporites auritus</i> (Zerndt) Bhardwaj, a middle Pennsylvanian lycopsid megaspore from southern Illinois, an ultrastructure study of	189
Vanstrum, Mark D.	242
Varner, V. K.	181
Vermeire, Patricia E.	235
Vigee, G. S.	198, 199, 200
Vitelli, Veronica A.	209, 210
Walker, Donna	224
Walker, Robert C.	211
Warren, W. H.	207
Wdowiak, Thomas J.	208
Weaver, David C.	205
Weed, John B.	260
Wender, Irving	68
Wesson, Kenneth R.	213
Wilborn, Walter H.	237
Williams, Carol	184
Wilson, H. J.	176, 176, 188
Wit, Lawrence C.	181, 182, 185, 186, 188, 189
Wood, Brian M.	214
Woody ornamental market, the competitive position of Alabama in the	210
X-ray crystal structures of compounds related to $(\eta^5\text{-C}_5\text{H}_4)\text{Cr}(\text{CO})_2(\text{NO})\text{C}(\text{OH})\text{CH}_3(\eta^5\text{-C}_5\text{H}_4)\text{Fe}(\eta^5\text{-C}_5\text{H}_5)$	195
X-ray crystallography to problems related to the pesticide aldrin and related compounds, the application of	196
<i>Yersinia enterocolitica</i> , ultrastructural studies of	191
Yielding, L. W.	197, 220
Yokley, Paul, Jr.	179
York, Randy J.	240

NOTES

77484
98

JOURNAL OF THE
ALABAMA ACADEMY OF
SCIENCE
VOLUME 50-51, 1979-80

RETURNED

Q11 JOURNAL OF THE
.J68 ALABAMA ACADEMY OF
* SCIENCE
VOL. 50-51, 1979-80

AMNH LIBRARY



100232704