

# Journal of the Arkansas Academy of Science

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Academy Editors

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**ARKANSAS  
ACADEMY OF SCIENCE**  
*Founded 1917*  
**p r o c e e d i n g s**

**Volume VIII** . . . . . **1955**

CONTENTS --VOLUME VIII

Program of 38th Annual Meeting - - - - -	109
Secretary's Report of 38th Annual Meeting - - - - -	113
Abstracts of Papers Presented at 38th Annual Meeting - - - - -	115
Cowpea and Bean Weevils. W. D. Wylie - - - - -	130
Cationic Activities and the Exchange Phenomena of Plant Roots; Relationship to Practical Problems of Nutrient Uptake. E. O. McLean, D. Adams, and F. E. Baker - - - - -	134
The House Fly Problem. J. L. Lancaster - - - - -	137
Laboratory or Busywork? Albert Robinson, Jr. - - - - -	141
An Annual Temperature Study of Five Northwest Arkansas Lakes. Carl E. Hoffman, Andrew Hulsey, Charles Nelson, Bobby Owen, and Buford Tatum - - - - -	144
Some Chemical Changes Resulting From Industrial Waste Disposal in the Ouachita River. Carl E. Hoffman - - - - -	149
A Study of the Cotton Rat in Northwestern Arkansas. John A. Sealander, Jr. and Barry Q. Walker - - - - -	153
The Possibility of Weak Alpha Branching in Radium D. B. R. Miccioli, R. R. Edwards, B. L. Robinson, and R. W. Fink - - -	163
Algebraic Relations for Property-Composition Curves of Binary Mixtures. Louis Frank - - - - -	165
Phase Equilibrium in the 1-Butene-Water System and Correlation of Hydrocarbon-Water Solubility Data. T. W. Leland - - - - -	168
Elementary Chemical Calculations. E. S. Amis - - - - -	170
The Use of Sales Tax Statistics in the Study of Economic Geography. William R. Brueckheimer - - - - -	173
Urban Land Classification. Eric S. Lane - - - - -	179
Delimitation and Analysis of the Little Rock Central Business District. James E. Vance - - - - -	181
Spatial Associations of the 1948, 1952 Presidential Vote. C. M. Strack -	190
The <i>Científicos</i> and the Collapse of the Diaz Regime: A Study of the Origins of Mexican Revolutionary Sentiment, 1903-1910. Walter N. Breyman - - - - -	192
An Exceptional Decision: The Trial of Professor Richard T. Ely by the Board of Regents of the University of Wisconsin, 1894. Stanley R. Holnick - - - - -	198
On Estimates of Error in Numerical Integration. Dorothy M. Hoover - - -	204
The Problem of Common Fungus Infections. Dr. Calvin J. Dillaha - - - -	208
Patients in Arkansas State Hospital from Two Arkansas Counties. Leta Adler - - - - -	211
Male Sex Behavior at a Southern University. L. R. Floerchinger - - - -	216

ARKANSAS ACADEMY OF SCIENCE

Thirty-Eighth Annual Meeting

University of Arkansas, Fayetteville

April 23-24, 1954

Friday, April 23

- 9:00 a.m. Registration
- 11:00 a.m. Meeting Called to Order, Dr. Z. V. Harvalik presiding. Welcoming address by Mayor Roy Scott of the City of Fayetteville, and Dr. Joe E. Covington, Acting President, University of Arkansas
- 12:30 p.m. Luncheon: Student Union  
Address: Philosophy and Science, Dr. Harold D. Hantz, Chairman, Department of Philosophy, University of Arkansas
- 2:00 p.m. \*Sectional Meetings: Agriculture, Biology, Chemistry, Geography, Geology, History and Government, Physics, Psychology, Mathematics, Medicine and Pharmacy, Sociology and Anthropology
- 2:15 p.m. Tour and Tea for Wives
- 4:00 p.m. -5:30 p.m. Open House
- 6:00 p.m. Dinner: Washington Hotel
- 7:00 p.m. Annual Public Lecture: Film, The Story of Mount Palomar, with comments by Dr. Bernard H. Gundlach, Mathematics Department, University of Arkansas.
- 8:30 p.m. -10:00 p.m. Science Fair
- 8:30 p.m. Film Short Subjects: Glass for Science  
The Development of Entomology

Saturday, April 24

- 8:30 a.m. Coffee and Doughnuts
- 9:00 a.m. Joint Meeting, Senior and Junior Academies of Science
- 10:30 a.m. Second Business Meeting: Treasurer's Report  
Report of Committees  
Election of Officers  
Adjournment
- 10:30 a.m. Modern Dance Preview (for wives)
- 12:00 m. Informal Luncheon: Student Union
- 1:30 p.m. Field Trip to Martin's Bluff on White River, arranged by Dr. Dwight Moore
- 1:30 p.m. Participation in Agri Day

\* SECTIONAL PROGRAM

Agriculture Section

Chairman: J. L. Lancaster, University of Arkansas

- A-1-1 Relative Biological Value of the Proteins in Cereal Grains, Buckwheat, and Grain Sorghums. Barnett Sure, University of Arkansas.
- A-2-2 A Cladosporium Leaf Blight of Oats Apparently New to Science. H. R. Rosen, University of Arkansas.
- A-3-3 Modification of the Environment as a Factor in the Control of Cotton Diseases. V. H. Young, University of Arkansas.
- A-4-4 Methods for Estimating the Clay Mineral Content of Certain Arkansas Soils. C. E. Lee and C. L. Garey, University of Arkansas.
- A-5-5 Cowpea and Bean Weevils. W. D. Wylie, University of Arkansas.
- A-6-6 Measurement of Cation Exchange Between Soil Colloids and Plant Roots. D. A. Brown and J. C. Noggle, University of Arkansas.

- A-7-7 Cationic Activities and the Exchange Phenomena of Plant Roots; Relationship to Practical Problems of Nutrient Uptake. E. O. McLean, D. Adams, and F. E. Baker, University of Arkansas.
- A-8-8 The Quality of Water from the Arkansas River for Irrigation Purposes. Cecil Blackwell, University of Arkansas.
- A-9-9 The Control of White Tip of Rice by Seed Treatments. G. E. Templeton and E. M. Cralley, University of Arkansas.
- A-10-10 The House Fly Problem. J. L. Lancaster, University of Arkansas.

## BIOLOGY SECTION

Chairman: Robert S. Fairchild, University of Arkansas

- B-1-11 Notes on Arkansas Amphibians and Reptiles. Herndon G. Dowling, University of Arkansas.
- B-2-12 Laboratory or Busywork? Albert Robinson, Jr., Arkansas State College.
- B-3-13 A Description of the Larvae of the Salamander *Ambystoma Annulatum*. Robert S. Chase, Jr., University of Arkansas.
- B-4-14 Preliminary Studies of the Rotifer Genus *Asplanchna*. Jack E. Atkins and Carl E. Hoffman, University of Arkansas.
- B-5-15 Observations on *Anemone* in Arkansas. Dwight M. Moore, University of Arkansas.
- B-6-16 Cytological Observations on Protaminobacter. Nelia Leurs, University of Arkansas.
- B-7-17 Physiological Studies on Slime Mold Plasmodia, George T. Johnson, University of Arkansas.
- B-8-18 Preliminary Report on Investigations of "Maternal Effects" in the growth of Hybrid Corn Embryos. Robert S. Fairchild, University of Arkansas.
- B-9-19 Evolution in the Western North American Cleomoideae. Hugh H. Iltis, University of Arkansas.
- B-10-20 The Vegetation of the White River Basin to be Affected by the Table Rock Dam and Reservoir. Dwight M. Moore, University of Arkansas.
- B-11-21 An Ecological Study of the Massard Prairie. Ruth Armstrong, Fort Smith Junior High School.
- B-12-22 An Annual Temperature Study of Five Northwest Arkansas Lakes. Carl E. Hoffman, Andrew Hulsey, Charles Nelson, Bobby Owen, and Buford Tatum, University of Arkansas.
- B-13-23 Some Chemical Changes Resulting from Industrial Waste Disposal in the Ouachita River. Carl E. Hoffman, University of Arkansas.
- B-14-24 A Study of the Cotton Rat in Northwestern Arkansas. John A. Sealander, Jr., University of Arkansas, and Barry Q. Walter, University of Arkansas and Western Reserve University.

## CHEMISTRY SECTION

Chairman: Joseph E. Pryor, Harding College

- C-1-25 Partial Vapor Pressures and Classical Acid Constant of Hydrogen Chloride. C. W. McCarty, Ouachita College.
- C-2-26 The Possibility of Weak Alpha Branching in Radium D. B. R. Miccioli, R. R. Edwards, B. L. Robinson, and R. W. Fink, University of Arkansas.
- C-3-27 Large Carbon-Ring Compounds. L. I. Duiguid, Du-Good Chemical Laboratory, St. Louis.
- C-4-28 A Possible Role of Radioactivity in Petroleum Genesis. R. R. Edwards and P. K. Kuroda, University of Arkansas.
- C-5-29 Algebraic Relations for Property-Composition Curves of Binary Mixtures. Louis Frank, Philander Smith College.
- C-6-30 A Product Study of the Distribution of  $C^{14}$  Produced During Neutron Irradiation of Sodium Cyanide. Arthur Fry, University of Arkansas.

- C-7-31 Phase Equilibrium in the 1-Butene-Water System and Correlation of Hydrocarbon-Water Solubility Data. T. W. Leland, University of Arkansas.
- C-8-32 The Reaction of Triphenylsilane with Organolithium Compounds. H. W. Melvin, Arkansas A. M. and N. College.
- C-9-33 Radium Isotopes in Uranium Minerals. P. K. Kuroda and R. R. Edwards, University of Arkansas.
- C-10-34 Elementary Chemical Calculations. E. S. Amis, University of Arkansas.

## GEOGRAPHY SECTION

Chairman: C. M. Strack, Henderson State Teachers College

- G-1-35 The use of Sales Tax Statistics in the Study of Economic Geography. William R. Brueckheimer, Southern State College.
- G-2-36 Geography of Arkansas: A Resource Unit. Clarence S. Williams, Arkansas State Teachers College.
- G-3-37 Urban Land Classification. Eric S. Lane, University of Arkansas.
- G-4-38 Delimitation and Analysis of the Little Rock Central Business District. James E. Vance, University of Arkansas.
- G-5-39 Spatial Associations of the 1948, 1952 Presidential Vote. C. M. Strack, Henderson State Teachers College.

## GEOLOGY SECTION

Chairman: Kern C. Jackson, University of Arkansas

- G1-1-40 The Stratigraphy of the Monticello Ridge. Frank E. Onellion, University of Arkansas.
- G1-2-41 A Heavy-Mineral Study of the Latest Cretaceous and Earliest Tertiary Formations of Central Utah. Kwang-yuan Lee, University of Arkansas.
- G1-3-42 Carbonate Fillings in Solution Cavities of Pre-Atoka Age. Kern C. Jackson and James E. Case, University of Arkansas.
- G1-4-43 Stratigraphy of the Hale Formation in Madison, Newton, Boone, and Carroll Counties, Arkansas. Douglas Scougale, University of Arkansas.
- G1-5-44 The Establishment of the Presence of the Miocene on Crowley's Ridge, St. Francis County, Arkansas. Ellis Doyle Herron, University of Arkansas.
- G1-6-45 The Petrogenetic Significance of Quartz Twins. Kern C. Jackson, University of Arkansas.

## HISTORY AND GOVERNMENT SECTION

Chairman: F. M. Bridge, University of Arkansas

- H-1-46 The *Cientificos* and the Collapse of the Diaz Regime: A Study of the Origins of Mexican Revolutionary Sentiment, 1903-1910, Walter N. Breyman, Southern State College.
- H-2-47 An Exceptional Decision: The Trial of Professor Richard T. Ely by the Board of Regents of the University of Wisconsin, 1894, Stanley R. Rolnick, Southern State College.
- H-3-48 The Idea of Progress in Recent Philosophy of History, Georg G. Iggers, Philander Smith College.
- H-4-49 Relationship of Planning and Zoning in the Arkansas Zoning Cases. Nathalie Georgia, University of Arkansas.
- H-5-50 The Know Nothings. Charles G. Hamilton, College of the Ozarks.

## MATHEMATICS SECTION

Chairman: N. A. Goldsmith, Henderson State Teachers College

- M-1-51 Derivation and Integration of Functions of Intervals, William S. Orton, University of Arkansas.
- M-2-52 On Estimates of Error in Numerical Integration, Dorothy M. Hoover, University of Arkansas.

- M-3-53 A Newcomer's Views on the Teaching of Elementary College Mathematics, Lowell R. Tappan, University of Arkansas.
- M-4-54 Let's Give Them What They Need. T. M. Simpson, Henderson State Teachers College.
- M-5-55 A Report on the Summer Conference on Collegiate Mathematics, Lyle J. Dixon, Arkansas State College.

MEDICINE AND PHARMACY SECTION

Chairman: Dr. Jacob Sacks, University of Arkansas

- MD-1-56 The Problem of Common Fungus Infections. Dr. Calvin J. Dillaha, Little Rock.
- MD-2-57 Studies on the Metabolism of Chick Bone Marrow, Dr. James S. Dinning, University of Arkansas School of Medicine.
- MD-3-58 A Study of Eclampsia With an Appraisal of the Current Therapy. Dr. Donald E. Barlow, University of Arkansas School of Medicine.
- MD-4-59 The Preparation of Cell-free Enzymes from the Photosynthetic Bacterium *Rhodospseudomonas Gelatinosa*. Arthur A. Smith and Dr. Jack M. Siegel, University of Arkansas School of Medicine.
- MD-5-60 Energy Requirement in Bacterial Photosynthesis. Dr. Jack M. Siegel, University of Arkansas School of Medicine.

PHYSICS SECTION

Chairman: J. Robbins, Hendrix College

- P-1-61 The Electret, an Electrical Analogy to the Permanent Magnet, C. E. Jones, University of Arkansas.
- P-2-62 Applications of Atmospheric Radioactivity to Meteorological Problems, Paul E. Damon, University of Arkansas.
- P-3-63 The Design and Use of a Cosmic Ray Telescope, C. C. Allen, University of Arkansas.
- P-4-64 A New Condenser Method for Determining Amplitudes of Light Diaphragmatic Materials. Lloyd B. Ham, University of Arkansas.
- P-5-65 Reflectivity of Metal Films Deposited at Various Low Pressures. Zabaj V. Harvalik, University of Arkansas.

PSYCHOLOGY SECTION

Chairman: Merrell E. Thompson, University of Arkansas

- PS-1-66 Reminiscence as a Joint Function of Directions and Distribution of Practice. Merrell E. Thompson, University of Arkansas.
- PS-2-67 The Effect of Time of Exposure to an Anxiety-Arousing Conditioned Stimulus, Robert S. Hicks, University of Arkansas.
- PS-3-68 The Medical College Admissions Test Score as a Criterion for Admission to Medical School. Edmond F. Erwin, University of Arkansas.
- PS-4-69 Directed Attention in Rote Serial Learning. Frank P. Gatling, University of Arkansas.

SOCIOLOGY AND ANTHROPOLOGY SECTION

Chairman: Fred W. Voget, University of Arkansas

- S-1-70 Patients in Arkansas State Hospital From Two Arkansas Counties. Leta Adler, University of Arkansas.
- S-2-71 Male Sex Behavior at a Southern University. L. R. Floerchinger, University of Arkansas.
- S-3-72 Land Tenure Process in the Arkansas Coastal Plain. J. L. Charlton, University of Arkansas.
- S-4-73 The American Indian in Transition. F. W. Voget, University of Arkansas.

ARKANSAS ACADEMY OF SCIENCE

Secretary's Report

Thirty-eighth Annual Meeting

University of Arkansas, Fayetteville

April 23-24, 1954

The business meeting was called to order by President Z. V. Harvalik at 11 a. m., April 23, with about 80 people present. Mayor Roy Scott, Fayetteville, and Provost Joe Covington, University of Arkansas, welcomed members of the Academy and expressed the interest of the University and of the City in the meetings.

Reports were given by several Academy officers. C. R. Cheadle, Managing Editor, announced that the Proceedings of the Academy was delayed in press and would be distributed later. Some financial support from advertising was obtained for this issue.

An abridged treasurer's report was read by L. F. Bailey, Acting, and the secretary's report was approved for inclusion in the Proceedings.

Dr. D. M. Moore reported on the Academy Conference and some of the activities. The Arkansas Academy has eighteen members designated as "Fellows" of the AAAS and eligible to be delegates to the annual Christmas meeting of the Academy Conference.

The Fayetteville High School Science Club, represented by Greg Payne, was accepted for affiliation with the Academy. The club was organized in September, 1953, and has fifty-three members.

Dr. C. E. Hoffman, Editor-in-Chief, stated that manuscripts should be received by the editor by June 1 to be accepted for publication.

The luncheon at the Student Union was attended by about one hundred people. Dr. H. D. Hantz, Chairman, Department of Philosophy, University of Arkansas, talked to the group on "Philosophy and Science." Various committees were appointed at this time.

Dr. B. H. Gundlach, Mathematics Department, University of Arkansas, presented the film "The Story of Mt. Palomar" at the annual dinner held at the Washington Hotel. Ninety people attended the dinner.

The second business meeting began at 10:30 a. m., April 24, with Dr. Harvalik presiding and about forty members attending. Committee reports received first attention.

The committee on the place of meeting for the spring of 1955 consisted of J. H. Ray, G. G. Iggers, and J. M. Siegel. This committee recommended that the meeting be held at Little Rock, sponsored jointly by Little Rock Junior College and Philander Smith College. An invitation to meet at Harding College, Searcy, was presented by J. W. Sears. A majority of those present voted to meet at Searcy in 1955.

Chairman C. G. Pitner, of the Audit Committee, approved the treasurer's report and recommended and obtained acceptance of the report by unanimous vote.

The Resolutions Committee, consisting of H. W. Melvin, G. T. Blackmon, and J. E. Pryor, made the following report.

\* The Committee on Resolutions of the thirty-eighth meeting of the Arkansas Academy of Science moves that this body adopt the following resolutions:

1. That the Academy express to the University of Arkansas its deep and sincere appreciation for the gracious hospitality extended to it through use of its plant and facilities as well as its personnel in making this session an outstanding success.

2. That the Academy further express to Dr. Z. V. Harvalik its fullest thanks for his capable leadership as its President during the past year.

3. That the Academy also express to Dr. W. J. Smothers its deep gratitude for effectively serving as its Secretary-Treasurer until his recent resignation from the University faculty and to Dr. L. F. Bailey for his diligent service as Acting Secretary-Treasurer.



4. That the Academy express to Dr. C. E. Hoffman, Editor-in-Chief, and to C. R. Cheadle, Managing Editor, its sincere gratitude for their arduous and unselfish work in publishing the Proceedings.

5. That the Academy further express to Dr. H. Chessin and to Dr. A. E. Harvey its appreciation for their work on the program and physical arrangements, respectively, for this session.

6. That the Academy express to Dr. J. A. Daugherty its thanks for his untiring efforts in developing the Arkansas Junior Academy of Science and to Dr. H. G. Dowling its thanks for his work with the Junior Academy before and during this session.

7. That the Academy also express to Mayor Roy Scott and the city of Fayetteville its deep appreciation for the hospitable reception of its members."

On a motion and vote from the floor the Secretary was instructed to send letters to Dr. H. D. Hantz and Dr. B. H. Gundlach expressing the appreciation of the Academy for their contributions to the program.

President Harvalik introduced the topics of membership and publication of the Proceedings for discussion. He clarified the categories of membership, according to the Academy Constitution, as follows:

1. Senior members - \$3 annually, including a copy of the Proceedings.
2. Associate members - \$1 annually, not including the Proceedings, and open only to students.
3. Institutional members - \$10 annually.

Professor Sears proposed that an effort be made the coming year to encourage larger membership in the Academy. Dr. Hoffman, with the support of others, suggested that membership forms be distributed early in January rather than waiting for the spring meeting to solicit membership. With this arrangement members would be actively associated with the Academy year after year regardless of attendance at the annual meeting.

Publication of the Proceedings of the Academy received considerable discussion in the second business meeting. At issue was the practice of distributing the Proceedings of the meeting held a year earlier in return for dues paid the current year. The undesirability of this practice was recognized generally by those present. Several members pointed out that additional revenue would be required to bring the publication to current status and expressed concern about the feasibility of this additional financing. Professor Munn moved that beginning with the next issue of the Proceedings publication be made current rather than a year later. An amendment to this motion, made by Dr. Frye, was as follows: "Providing financing can be arranged without incurring indebtedness". The motion with the amendment was passed. Dr. Harvey proposed that a committee be appointed to explore possible means of financing the proposed change in publication practice and that this committee should report to the Academy next year. With this proposal the matter was suggested for inclusion on the agenda of the next business meeting.

The Nominations Committee, J. W. Sears, D. Swartz, and W. C. Munn, presented the names of W. W. Nedrow and J. E. Pryor for President-elect, and L. F. Bailey for Secretary Treasurer. Professor Nedrow and Dr. Bailey were elected.

The Research Committee received only one application for the AAAS research grant of fifty dollars. Dr. Harvalik's Project, "The Reflectivity of Metal Films Deposited at Various Low Pressures" was accepted. This committee consisted of C. E. Hoffman, E. S. Amis, and H. Shniad.

Dr. Harvalik officially installed Miss Ruth Armstrong, Chairman of the Science Department, Fort Smith Junior High School, as the new President. Miss Armstrong expressed appreciation of the honor bestowed by the Academy and indicated her desire to see the Academy prosper during the coming year.

With the announcement of the afternoon field trip, directed by Dr. D. M. Moore, the business meeting adjourned at 11:40 a.m.

Lowell F. Bailey  
Acting Secretary-Treasurer

ABSTRACTS OF PAPERS PRESENTED  
AT THE THIRTY-EIGHTH ANNUAL MEETING

University of Arkansas, Fayetteville  
April 23-24, 1954

AGRICULTURE SECTION

Chairman: J. L. Lancaster, University of Arkansas

A-1-1

Relative Biological Value of the Proteins in Cereal Grains, Buckwheat, and Grain Sorghums. Barnett Sure, University of Arkansas.

This study was conducted on the Wistar-strain albino rat. The period of experimentation was 10 weeks. The yardstick for evaluation was protein efficiency ratios (PER), expressed as gains in body weight per gram of protein intake. There were 24 animals in each group.

On 9 per cent protein intake, the PER for whole hard-wheat flour was 1.05, and for whole rye flour, 1.45. On 5 per cent protein intake, the PER for the wheat was 0.95; rye, 1.95; and whole yellow corn, 0.50. On 8 per cent protein intake, the PER for rolled oats was 1.67; Wisconsin whole buckwheat, 2.03; Wisconsin buckwheat flour, 2.06; Arkansas grain sorghum, 0.43; and Oklahoma grain sorghum, 0.29.

It is evident from this investigation that the proteins in rye are much more efficient than those in wheat, and as rye can grow on much poorer soils than wheat, more of this cereal grain should be cultivated for livestock and human consumption on millions of acres of waste lands.

But the most surprising revelation from this study is that the proteins in buckwheat have such a high biological value. Therefore, serious consideration should be given to increased production of this crop. It is apparent also that the proteins in the grain sorghums are of very poor biological value.

A-2-2

A Cladosporium Leaf Blight of Oats Apparently New to Science. H. R. Rosen, University of Arkansas.

A highly destructive disease of oats was first observed at the University Farm near Fayetteville in March, 1953, on a new oat variety, Woodward Composite, C15106. Of over 1,500 oat varieties and selections, this variety was the only one found infected, indicating that the disease and its causal agent is highly selective. By late March, fully 50 to 75 per cent of the leaf area was killed on all plants of this variety, including every row of three randomized replicates with three-rod rows in each replicate. The lowermost leaves were completely killed, but as the disease progressed upwards dead areas on sheaths and blades became less abundant.

Individual lesions appear at first as small, grayish-green, depressed, irregular spots which dry rapidly into dead, tan-colored areas. When such spots coalesce, large, reddish-yellow halos surround them so that two-thirds or more of the blade becomes discolored. In young infections there are no surface signs of any pathogen, but on older infections dark-colored tufts appear, representing the fruiting stage of a species of Cladosporium. Single-spore isolates grow readily on standard PDA, producing dark-colored, slow-growing colonies at temperatures around 20°C. When a spore suspension of such colonies in sterile water is sprayed on young seedlings of Woodward Composite, numerous leaf infections appear.

A-3-3

Modification of the Environment as a Factor in the Control of Cotton Diseases. V. H. Young, University of Arkansas.

Many diseases of cotton are severe under certain environmental conditions such as suboptimal temperatures and malnutrition due to soil deficiencies. Our

work with cotton diseases has involved determination of the effect of environment on the etiology of cotton diseases, and the amelioration of unfavorable conditions through cultural practices.

Earlier work dealt with Fusarium-wilt control by reducing potash hunger or "rust." Fusarium wilt was brought under satisfactory control except where root-knot was a serious factor. Our recent work with soil fumigants indicates that they can now be recommended for control of the Fusarium-wilt/root-knot complex.

Work on Verticillium wilt is incomplete but certain facts have emerged. Deep cultivation causes root injury, rendering cotton susceptible to the disease. Elimination of anything beyond shallow scraping greatly reduces the incidence and severity of the disease and gives increased yields. Fertilizer studies show that high nitrogen applications render cotton more susceptible to attacks of Verticillium wilt. Applications of complete fertilizers seem more promising, but severe wilt conditions have not arisen since this work was started, and definite recommendations await more severe tests. Similar work on other parasitic and non-parasitic diseases is planned.

A-4-4

Methods for Estimating the Clay Mineral Content of Certain Arkansas Soils. C. E. Lee and C. L. Garey, University of Arkansas.

A study is being conducted to identify the minerals in the clay fraction of several Arkansas soils. Methods of study now in use in other soil laboratories have been adopted and modified with certain improvements to give greater accuracy and to reduce the amount of labor required.

X-ray analysis, differential-thermal analysis, and total-exchange-capacity measurements have been made on each sample of clay being studied. Standard mixtures of known, relatively pure clays have been prepared and studied by these methods. By proper control of the procedures, the ratios of intensity of the major peaks of kaolinite, montmorillonite, and quartz have been related to the percentage composition of each in the mixture. By comparing the data from soil-clay separates with that from the pure mineral mixtures, an estimate of the amount of each mineral group in the soil can be made.

This information may be useful in providing a better understanding of the chemical and physical reactions which take place in the soil, and in assisting in the future solution of soil problems.

A-6-6

Ionic Exchange in Soils: II. Measurement of Cation Exchange between Soil Colloids and Plant Roots. D. A. Brown and J. C. Noggle, University of Arkansas.

The desirability of developing techniques for measuring the exchange reaction between soil colloids and plant roots has been previously reported. More recently techniques have been perfected which enable a quantitative measurement of the exchange reaction between the soil and growing plant roots.

The purpose of this paper is to report the effects of nutrient status of the soil upon the suite of cations taken up by plants. Soybeans were grown for four weeks in Crowley silt-loam soil and Sharkey clay. These soils had been treated to give 5 levels of magnesium saturation (0, 3, 6, 12, 18%) and repeated for 3 levels of potassium saturation, 1.5, 3.0, and 6.0% for the Crowley soil, and 0.75, 1.5, and 3.0% for the Sharkey soil. Data are reported in terms of the suite of cations adsorbed by plant roots, and their absorption into the roots and tops of the plants. The suite of cations was altered markedly as either the magnesium or potassium levels in the soil were changed. The influence of the type of clay mineral upon the exchange of potassium, calcium, and magnesium from the soil to the plant roots was also quite evident for any given degree of cation saturation. The significance of these data in fertilizer practices is discussed.

A-8-8

The Quality of Water from the Arkansas River for Irrigation Purposes. Cecil Blackwell, University of Arkansas.

According to surveys conducted by the Water Resources Laboratory of the University of Arkansas, water from the Arkansas and Red Rivers may be unsafe for

irrigation purposes at certain times during the year. In general, the dissolved-mineral-salts content can be expected to be higher during periods when the Arkansas River is at low stage. This does not always hold true. However, since the time that irrigation water is most needed usually coincides with low stage of the river, it is generally considered unsafe to use this water for irrigation.

In the fall of 1953, a preliminary experiment was initiated in the greenhouse at Fayetteville involving three soil types and three sources of water. The soils were sandy loam, silt loam, and silty-clay loam taken from river bottom land in Sebastian County near Van Buren. The water sources were distilled water, tap water and water from the Arkansas River at Van Buren. These waters were analyzed for conductance and mineral-salts content by the Water Resources Laboratory and the soil samples were analyzed by the Soil Testing Laboratory. This study is designed to determine the possible interaction of soil type and water source on the performance of snap beans and their absorption of nutrients. It is also hoped to obtain some indication of the effects of river water on the physical and fertility condition of these soils. These data are still in the analysis stage, and it is not possible to give a complete summary of the results at this time. Arkansas River Water has caused a stunting of plant growth, and on one soil the plants developed a marginal leaf burn which may prove to be sodium toxicity or possibly a potassium deficiency due to the excessive uptake of sodium.

## A-9-9

The Control of White Tip of Rice by Seed Treatments. G. E. Templeton and E. M. Cralley, University.

White tip (*Aphelenchoides* sp.), a serious disease of rice, is caused by a seed-borne nematode. Previous work has shown that the organism is not soil borne. Therefore, experiments are in progress to determine the effect of various nematocides, applied as seed treatments, on the severity of the disease.

N-244 (3-p-chlorophenyl-5methyl rhodamine), applied to rice seed at the rate of one and one-fourth ounces per bushel (40% formulation), has effectively controlled white tip of rice growing under greenhouse and field conditions. HL737 (2-nitro-1-furylphenylene), applied at the rate of four ounces per bushel (10% formulation), and Ridsaan II (p-phenylene bisrhodanine), applied at the rate of one-half ounce per bushel (technical grade) showed promise for the control of white tip in screening tests.

The above compounds have not been toxic to rice seedlings when applied at the rates specified. Preliminary tests with N-244 indicate that this compound is compatible with seed-treatment fungicides such as Arasan and Ceresan M. which are commonly applied for the control of seedling diseases. Yields of susceptible rice varieties, when the seed is heavily infested with nematodes, have been increased by five to ten bushels per acre by seed treatments with N-244.

## BIOLOGY SECTION

Chairman: Robert S. Fairchild, University of Arkansas

## B-1-11

Notes on Arkansas Amphibians and Reptiles. Herndon G. Dowling, University of Arkansas.

A summary of the knowledge of Arkansas amphibians and reptiles, with discussion of the work now in progress. The distribution of several of the forms within the state is indicated.

## B-3-13

A Description of the Larvae of the Salamander *Ambystoma Annulatum*. Robert S. Chase, Jr., University of Arkansas.

The larvae of the salamander *Ambystoma annulatum* have not been described in their early stages of development because of the lack of information about both range and life history of the species. However, eggs were laid and the described larvae cultured in the laboratory, removing any doubt as to their origin. None of the larvae survived beyond 48 days after hatching. The description is based on these individuals.

## B-5-15

Observations on *Anemone* in Arkansas. Dwight M. Moore, University of Arkansas.

*Anemone quinquefolia*, a species of the eastern and northern states, has been found in a very restricted habitat at Blanchard Spring, Stone County.

*Anemone caroliniana*, common in many other states, is widely distributed in Arkansas. Another species, assigned to *Anemone decapetala* Ard., is native to Chile and other South American countries. The specimens found in Marion, Fulton, and Little River counties seem to differ from material from those countries. This species listed in the Seventh Edition as "doubtfully distinct", has been excluded from the Eighth Edition of Gray's Manual, but as our material is distinct from *A. caroliniana* and also appears to differ from the South American *A. decapetala*, it must be considered as either a variety of that species, or as a new or a different species. Studies are being continued on its exact nature. Other collections of these are solicited.

## B-8-18

Preliminary Report on Investigations of "Maternal Effects" in the Growth of Hybrid Corn Embryos. Robert S. Fairchild, University of Arkansas.

The nature and magnitude of the effects of genetically different endosperms on the growth of reciprocal hybrid corn embryos might be determined by observations of the growth of excised embryos in nutrient cultures.

Reciprocal crosses involving inbreds of dent, pop, and sweet corn were made, and both inbred and hybrid embryos were transferred to nutrient agar-culture media when less than ten days old. Macroscopic observations of comparative growth were made.

## B-9-19

Evolution in the Western North American Cleomoideae. Hugh H. Iltis, University of Arkansas.

The four genera of western North American Cleomoideae (Capparidaceae) can be arranged in a phyletic-reduction series based on fruit, raceme, and bract structure. This series, from the primitive *Cleome*, sect. PERITOMA (6 spp.) through the progressively more specialized *Cleomella* (9 spp.) and *Wislizenia* (1 sp.) to the highly specialized *Oxystylis* (1 sp.) is remarkably complete. The reduction runs from many-seeded siliques through few-seeded silicles to two-seeded schizocarps, and from open, bracteate racemes through denser, ebracteate ones to congested, ebracteate raceme-clusters.

The geographic distributions imply these reductions to be due to adaptive evolution through selection by an arid environment. The primitive forms are widely distributed in more mesic climates; the specialized have progressively smaller, essentially equiformal areas centering about the Death Valley of California where *Oxystylis* is endemic. The ranges and relationships of individual taxa within each genus follow a pattern corresponding to their morphology. The taxa of the primitive (therefore oldest) genus *Cleome* are all sympatric and sharply distinct; of the more specialized genus *Cleomella* both allopatric and sympatric and less sharply distinct; and of the monotypic, polymorphic *Wislizenia*, allopatric with closely related populations. The most specialized (therefore youngest) monotypic *Oxystylis* is monomorphic.

The suggestion is made that in evolution through isolation, taxa of a genus have to be allopatric before they can become sympatric, and that by studying the ranges of the genera, we can corroborate geographical distinction with the morphology and relative age of a genus. The fact that there are different kinds of genera can in part be explained by the differences in their age. A concept of "accelerative evolution" concomitant with increased specialization of morphology and habitat is suggested by this series.

## B-10-20

The Vegetation of the White River Basin to be Affected by the Table Rock Dam and Reservoir. Dwight M. Moore, University of Arkansas.

During the summer of 1953 the writer, with the very capable cooperation of Dr. Hugh Iltis and the assistance of one of our students, James Mize, made a

study of the area to be affected by the building of Table Rock Dam on White River in Taney County, Missouri. The lake to be formed will cover an area of approximately 52,300 acres at the flood-control level, and the White River will be backed up for a distance of approximately 77 miles to a point near the present crossing of that river by U. S. Highway 62, about ten miles west of Eureka Springs.

Much of the area affected is in the Cotter dolomite, and this has shown marked effects on the vegetation. Striking differences are observable on contrasting slopes such as those facing north or east in contrast to those facing south or west. Representative stations were selected from near the dam site up to the head of the lake, and those were studied in considerable detail.

Of the plants found in the area, the following table is fairly indicative of the variety observed:

Pteridophytes	17 genera, including 26 species
Gymnosperms	3 (2 genera).
Monocots	110 species representing 12 families, including 70 grasses in 33 genera, of which 19 were species of <i>Panicum</i> . Fourteen species of <i>Cyperaceae</i> , and 26 other species.
Dicots	433 species from 79 families. Of these there were 70 <i>Compositae</i> , 39 <i>Leguminosae</i> , 20 <i>Labiatae</i> , 18 members of the <i>Euphorbiaceae</i> , 15 <i>Umbelliferae</i> , 15 <i>Ranunculaceae</i> and <i>Scrophulariaceae</i> , with smaller numbers in other families.

Some new distribution records were made, of which the most unexpected was a large stand of overcup oak (*Quercus lyrata*) in an old oxbow of Long Creek, less than two miles above the dam site.

## B-11-21

An Ecological Study of the Massard Prairie. Ruth Armstrong, Fort Smith Junior High School.

This paper presents a study of the vegetation of Massard Prairie and conditions existing there over the growing season. Seasonal rainfall, temperature, evaporation, length of daylight, and flower appearance were studied. A list of plants found on the prairie is included.

## CHEMISTRY SECTION

Chairman: Joseph E. Pryor, Harding College

## C-1-25

Partial Vapor Pressures and Classical Acid Constant of Hydrogen Chloride. C. W. McCarty, Ouachita College.

The partial vapor pressures of hydrogen chloride, over aqueous solutions, were determined from electromotive-force data at 10, 25, 40, 50, and 60° C. The values so obtained compare favorably with the experimental values recorded in the International Critical Tables, especially at 25°. The deviation of these calculated and experimental values seem to be a function of the temperature.

The concentration of the undissociated portion of the hydrogen chloride was determined from the calculated partial vapor pressure, assuming that Raoult's law holds. Using these concentrations and the activity coefficients as determined by Harned and Ehlers, the values for the classical acid constant were determined.

t°C	10	25	40	50	60
K°x10 <sup>-6</sup>	6.13	1.287	0.313	0.132	0.0589

The slope of the straight line graph of Log K° against 1/T gave a value of -17,200 calories for  $\Delta H$ . This indicates that a decrease in temperature favors dissociation, and that heat is liberated in the dissociation process.

## C-3-27

Large Carbon-Ring Compounds. L. I. Diuguid, Du-Good Chemical Laboratory, St. Louis.

In the last two decades considerable interest has been developed in the synthesis of large-ring compounds in the fields of medicine and in the perfume industry. Muscone and civetone are important bases that have been synthesized by Hamsdieker, Ruzicha, Ziegler and others.

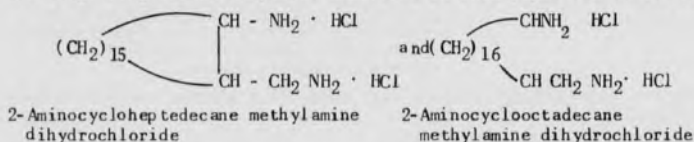
Also, work is being directed towards the synthesis of large-ring compounds having anti-leprosy properties. In connection with pharmaceuticals, this paper outlines the synthesis of some large-ring compounds of the perfume type, and some prepared for antimalarial tests. Other large-ring compounds containing as many as  $C_{34}$  have been synthesized.

The Ziegler method of cyclization at infinite dilution in a solvent such as ether was used, starting with even-numbered and odd-numbered carbon straight-chain dinitriles having  $C_{17}$ ,  $C_{19}$ , and  $C_{19}$  carbon atoms.

A new method is described for a more direct method for the synthesis of odd-numbered carbon, straight-chain dibasic acids, via the Ketene synthesis (Wedekinds method) in high yields. The method was published in the Journal of American Chemical Society, Vol. 74 (1952) 4203-4.

The even-numbered aliphatic dibasic acids were synthesized electrolytically via the Kolbe method.

The large-ring carbon compounds described in this paper are as follows:



## C-4-28

A Possible Role of Radioactivity in Petroleum Genesis. R. R. Edwards and P. K. Kuroda, University of Arkansas.

As the extensive studies of Whitehead, *et al.*, on the action of radiation on marine sediments have developed essentially negative results, it appears that the petroleum-genesis problem might be re-evaluated in terms of radiation-induced polymerization reactions on light hydrocarbons produced by bacterial action. Some recent experimental results of measurements of radioactivity in natural gases and petroleum brines will be discussed as related to this possibility. Samples of brines from the Burbank field, Osage County, Oklahoma, have shown radium concentrations up to  $10^{-9}$  curies per liter, which approaches one thousand times the radium concentration values in the Arkansas Hot Springs.

## C-6-30

A Product Study of the Distribution of  $C^{14}$  Produced During Neutron Irradiation of Sodium Cyanide. Arthur Fry, University of Arkansas.

The products formed in the irradiation of a sample of solid sodium cyanide in the Oak Ridge graphite reactor have been investigated in considerable detail. The most striking result of the investigation is that approximately fifty per cent of the total activity produced in the  $N^{14}(n,p)C^{14}$  reaction is found as sodium cyanide. This indicates a high probability that the recoiling  $C^{14}$  atom initially formed will displace carbon from cyanide ion. Most of the rest of the activity ends up in fractions which contain carbon-carbon bonds, possibly derived from displacement of nitrogen from cyanide ion. However, the resulting fragment does not end up as acetylene or sodium acetylide as might be expected, but as more complicated organic compounds, most of which are acidic in nature.

## C-8-32

The Reaction of Triphenylsilane with Arganolithium Compounds. H. W. Melvin, Arkansas A. M. and N. College.

Triphenylsilane,  $(C_6H_5)_3SiH$ , was found to react with  $RLi$  compounds to yield tetrasubstituted silanes of the type  $(C_6H_5)_3SiR$ .

An analogous reaction occurred when lithium amides were caused to react with triphenylsilane, resulting in derivatives of the type  $(C_6H_5)_3SiNR_2$ .

A proposed explanation for these reactions is based upon relative electronegativities.

## C-9-33

Radium Isotopes in Uranium Minerals. P. K. Kuroda and R. R. Edwards, University of Arkansas.

It was found that the ratio Ra-223 to Ra-226 in a carbon-uranium mineral (asphaltite from Temple Mountain, Utah) was slightly different from that in pitchblende (Great Bear Lake, Canada). Nuclear-geochemical factors which affect this ratio in natural uranium minerals will be discussed.

## GEOGRAPHY SECTION

Chairman: C. M. Strack, Henderson State Teachers College

## G-2-36

Geography of Arkansas: A Resource Unit. Clarence S. Williams, Arkansas State Teachers College.

The need for this type of unit is based on a survey of the curriculum offerings in the junior and senior high schools of Arkansas, and on the lack of consolidated Arkansas geographic materials for teacher use. A resource unit is one that not only offers background material pertaining to a specific subject, but also presents to the teacher various methods by which this material may have maximum usability.

The background materials on the geography of Arkansas have been assembled from various sources and will be compiled on an inventory basis. The inventory approach is used so that the teacher may select any part of the whole as a separate unit of study. The teaching aids will be based primarily on how this background material may be integrated into the existing curriculum, forms of motivation, and evaluation.

Even though the resource unit will be written for teacher use, the objectives of the unit are student-centered. It is hoped that this unit will lead to: a better understanding of the physical and cultural aspects of the state; an appreciation of the interaction of these aspects; and the development of the students' abilities to interpret both physical and cultural phenomena.

## GEOLOGY SECTION

Chairman: Kern C. Jackson, University of Arkansas

## G1-1-40

The Stratigraphy of the Monticello Ridge. Frank E. Onellion, University of Arkansas.

Located in southeastern Arkansas, the Monticello Ridge extends southward from southern Lincoln County, across Drew County, into northern Ashley County.

The Jackson formation, consisting of light-gray to bluish-gray clay in this area, crops out at places near the base of the ridge. The material that makes up most of the ridge consists of reddish-brown to yellowish-orange silt, silty sand and gravel, and orange to grayish-purple clay. The maximum thickness of the material is about 60 feet.

The sand and gravel is more or less cross bedded, and the nature of the deposits suggest deposition by water. Apparently the source of the material was from the northwest. The gravel, found as lenses and stringers in the sand beds,



consists almost wholly of chert pebbles. Fossils in the pebbles show that the chert is of Paleozoic age. In general, the gravel in the northern part of the ridge is coarser than that in the southern part.

Relationships are not known, but the material in the ridge apparently is not a part of the Jackson formation. It is similar to the sand and gravel that underlies the loess in Crowley's Ridge.

The gravel in Monticello Ridge is used for road material. The sand and gravel deposits furnish water to many domestic wells and springs, but because of the topographic position and the limited extent of the deposits, they will never be a source of large amounts of ground water.

G1-2-41

A Heavy-Mineral Study of the Latest Cretaceous and Earliest Tertiary Formations of Central Utah. Kwang-yuan Lee, University of Arkansas.

The heavy-mineral study of the latest Cretaceous and earliest Tertiary sediments has aimed (1) to determine the value of mineralogical composition of the sediments as a basis for differentiating the North Horn formation from the Price River formation as well as the overlying member of the Paleocene Flagstaff Limestone, and (2) to determine the mineralogical and lithological variations regionally and stratigraphically.

The mineral assemblages consist chiefly of tourmaline, zircon, garnet, staurolite, rutile, biotite, hornblende, apatite, corundum, spinel, fluorite, dolomite, glauconite, barite, iron-oxide, and leucoxene. Among them tourmaline, zircon, garnet, dolomite and iron-oxides are the principal minerals. Colorless overgrowths of tourmaline are attached to the brown and pink tourmalines at the negative poles of the crystals. Some zircons take the form of tooth-like serrations attached to the prism face. Intensely etched staurolites are noticed. On the basis of the heavy-mineral suite, five mineral zones are tentatively proposed for the purpose of correlation; these sediments were originally derived from acid to intermediate plutonic terraine and, to a minor extent, to some pre-Cambrian metamorphics in the Wasatch Mountain region. As a whole, the bulk composition of the sediments have passed through more than one cycle of erosion and deposition.

G1-3-42

Carbonate Fillings in Solution Cavities of Pre-Atoka Age. Kern C. Jackson and James E. Case, University of Arkansas.

A group of interesting carbonate masses in the Brentwood limestone (Morrow Age) are described. They are interpreted as having resulted from ground-water deposition in solution cavities. Their development is placed in the time interval represented in nearby areas by the Woolsey shale and Kessler limestone (Morrow Age).

G1-4-43

Stratigraphy of the Hale Formation in Madison, Newton, Boone, and Carroll Counties, Arkansas. Douglas Scougale, University of Arkansas.

The paper is a lithologic study of 25 stratigraphic sections of the Hale formation, measured at intervals of approximately six miles, in Madison, Newton, Boone and Carroll Counties.

As a result of the study, a detailed description of the regional stratigraphy plus a graphic cross section of the area, based on lithologic correlation, has been compiled.

G1-6-45

The Petrogenetic Significance of Quartz Twins. Kern C. Jackson, University of Arkansas.

Quartz twinning in granites was studied in order to determine if any interpretation of the origin of the granite could be made. Brazil-type twinning was found to be almost entirely lacking in rocks in which the granitizing processes had been carried to completion, and was found to be present in incompletely granitized and magmatic rocks. The explanation of this was sought in a consideration of the energy on the composition planes of brazil and dauphine twins.

## HISTORY AND GOVERNMENT SECTION

H-3-48

The Idea of Progress in Recent Philosophy of History. *Georg G. Iggers, Philander Smith College.*

Beginning with the seventeenth century, the conception of history in terms of linear progress became a dominant force in historical and philosophical thought. If in the eighteenth century this progress was still conceived as primarily intellectual and moral in character (Voltaire, Kant, Condorcet), nineteenth century philosophers of history, under the impact of Romantic conceptions of history, increasingly viewed progress in terms of total social development. Under the impact of Hegelianism, Marxian materialism, and post-Darwinian social evolutionism, the idea of inevitable social progress and of the possibility of applying the methods of the natural sciences to history became so dominant that even pragmatic historians and explicitly non-philosophic works, like the Cambridge Modern History, accepted the progressive character of history as a scientific fact.

This paper is concerned primarily with some phases of the revolt against the linear conception of progress since the nineteenth century. Rather than to give a scanty survey of the literature in twenty minutes, it will attempt to point out a number of problems contained in several basic concepts, such as "society," "culture," "civilization," "causation," "growth," and "decline," found in the works of three thinkers. Spengler and Toynbee are representative of modern cyclical theories which, while rejecting the idea of linear progress in human history, hold that within individual societies laws of development may be scientifically formulated. Jacob Burckhardt was representative of the skepticism concerning the possibility of a philosophy of history and the applicability of the methods of the natural sciences.

H-4-49

Relationship of Planning and Zoning in the Arkansas Zoning Cases. *Nathalie Georgia, University of Arkansas.*

Zoning is a tool to implement land-use plans. It is the purpose of this paper to discover, through a study of planning and zoning legislation and the court cases, how the Arkansas State Legislature and Supreme Court have observed this relationship. The State Legislature did not recognize the relationship at first, but subsequently enacted legislation which did. The decisions rendered by the Supreme Court, although not always consistent, show a trend toward recognition of the relationship.

H-5-50

The Know Nothings. *Charles G. Hamilton, College of the Ozarks.*

Nativism existed in the nation for many years before it found an organized expression in the Know Nothing Party. This party gained rapidly in the middle of the 1850's, and in the 1856 election it held the balance of power in several salient states.

The Republican Party sought these votes in state races as well as in the national arena. The nomination of a presidential candidate in 1860 by that party was influenced by those seeking to obtain the Know Nothing vote. The campaign also was marked by appeals to the Know Nothings. A study of the vote by counties, in such salient states as California, Indiana, Illinois, New Jersey, New York, Ohio, and Pennsylvania suggests that the Know Nothing votes of 1856 decided the election of 1860.

## MATHEMATICS SECTION

M-1-51

Derivation and Integration of Functions of Intervals. *William R. Orton, University of Arkansas.*

## I. Fundamental Definitions

## A. Intervals

1. Elementary System and Subdivision
2. Norm and Parameter of Regularity

- B. Functions of Intervals
  - 1. Extensions to More General Sets
  - 2. Continuity, Absolute Continuity, and Bounded Variation
- C. Theorems Concerning Fundamental Properties
  - 1. Covering Theorems
  - 2. Interrelations of Properties
- II. Derivation of Functions of Intervals
  - A. Ordinary Derivates
  - B. Examples of Derivable Functions
  - C. Theorems on Derivable Functions
- III. Integration of Functions of Intervals
  - A. General Burkill Integral
  - B. Examples of Integrable Functions
  - C. Properties of the Integral
- IV. Theorems Relating to Differentiation and Integration

M-3-53

A Newcomer's Views on The Teaching of Elementary College Mathematics. Lowell R. Tappan, University of Arkansas.

The views and problems presented in this paper are those of one who looks at the problematic situation from the double viewpoint of student and teacher.

Attention is focused upon these three particular questions:

- (1) What can be expected of students in elementary college mathematics courses in the way of background knowledge?
- (2) To what extent should 'grading on a curve' prevail in the elementary college mathematics courses?
- (4) Should students enrolled in different curricula of the various colleges be graded on the same basis in their elementary college mathematics courses?

The views here presented have been reached from experience in high-school teaching and subsequent knowledge of the state of mathematical training of the typical college freshman.

In the light of these views, certain personal opinions are offered in regard to the teaching of elementary college mathematics to such students.

M-4-54

Let's Give Them What They Need. T. M. Simpson, Henderson State Teachers College.

The paper presents suggestions for modifications of the problem content of the traditional freshman courses, and of the courses in General Education. It emphasizes the versatility and universality of mathematics as a tool. A plea is made for a substantial reduction in the proportion of problems from the areas of the physical sciences, and for a corresponding increase in that from biology, social studies, music and other fields.

M-5-55

A Report on the Summer Conference on Collegiate Mathematics. Lyle J. Dixon, Arkansas State College.

The University of Colorado was host to the Summer Conference on Collegiate Mathematics from June 15 to August 8, 1953, sponsored by the National Science Foundation.

The conference was divided into two parts. The first part consisted of two series of lectures for the entire eight weeks of the conference. One series was on Modern Developments in Algebra, by Professor Emil Artin, Princeton University. The other was on the Introduction to Modern Foundational and Topological Concepts via the Notion of Curve, by Professor R. L. Wilder, University of Michigan.

The second part of the conference consisted of a series of short lectures by various mathematicians. Of particular interest in regard to our own problems

was a short lecture series by Dr. Carroll V. Newsom, Assistant Commissioner of Education for the State of New York. These lectures were on the undergraduate curriculum in mathematics. In addition to his many interesting and pertinent remarks on this topic, Dr. Newsom outlined an entirely new curriculum for undergraduate majors in mathematics.

## MEDICINE AND PHARMACY SECTION

Chairman: Dr. Jacob Sacks, University of Arkansas

MD-2-57

Studies on the Metabolism of Chick Bone Marrow. Dr. James S. Dinning, University of Arkansas School of Medicine.

Chick-bone marrow exhibits choline oxidase and succinoxidase activities and incorporates choline into phospholipids *in vitro*. The latter reaction requires ATP. Choline oxidase is reduced or abolished by prior treatment of the animals with x-ray, urethane, or aminopterin. Bone marrow from folic-acid-deficient chicks is devoid of choline oxidase, but incorporates choline into phospholipids at an accelerated rate.

MD-3-58

A Study of Eclampsia With an Appraisal of the Current Therapy. Dr. Donal E. Barlow, University of Arkansas School of Medicine.

The problem of Eclampsia is defined and briefly discussed. The etiology is still unknown in its entirety. Therefore, it seemed wise to review the literature with the principal objective of consolidating recent findings of other observers and combining these with the findings of a controlled study made by the Department of obstetrics and Gynecology, University of Arkansas School of Medicine. This study, completed in December, 1953, includes 107 patients with Eclampsia.

Eclampsia has three major clinical manifestations -- edema (swelling), hypertension (high blood pressure), and convulsions that are followed by coma. The principal objective of our study was to determine the effect on the course of Eclampsia when each of these manifestations was controlled -- one at a time. A fourth group of patients was studied, with the treatment limited to hospitalization and bed rest only. This review and comparative study has given us a different concept of Eclampsia.

MD-4-59

The Preparation of Cell-free Enzymes from the Photosynthetic Bacterium *Rhodospseudomonas Gelatinosa*. Arthur A. Smith and Dr. Jack M. Siegel, University of Arkansas School of Medicine.

Cells of *Rhodospseudomonas gelatinosa* catalyze the carboxylation of acetone to acetoacetate and the cleavage of acetoacetate to acetate. Preliminary efforts have been made to obtain cell-free enzyme preparations for a more detailed study of these reactions. The methods of preparation that have been attempted include grinding with powdered glass, preparation of acetone powders, and grinding with alumina. Of these, the alumina-grinding technique gave the highest enzyme activity. This preparation can be stored in the frozen state for a week or more without loss of activity, and is stable for several hours at 30°C. The decomposition of acetoacetate by this preparation was stimulated by the addition of adenosine triphosphate (ATP) and succinate, but not by the addition of coenzyme A. The effect of added ATP, however, was obscured by the presence of an active ATPase.

MD-5-60

Energy Requirement in Bacterial Photosynthesis. Dr. Jack M. Siegel, University of Arkansas School of Medicine.

The present investigation deals with the effect of organic substrates on energy requirements in bacterial photosynthesis. The discussion will be limited primarily to the results of 3 experiments. (1) In the absence of oxygen and light, the bacteria catalyze a reversible cleavage of acetoacetate to acetate. The reverse reaction, however, is stimulated by light. (2) The incorporation of acetate into more complex substances, in the absence of oxygen and light, is

greatly stimulated by the presence of acetoacetate. (3) The photosynthetic rate versus light-intensity curve consists of two distinct components below light saturation. The two components correspond to a high quantum-yield process at low light intensities, and to a low-quantum yield process at high light intensities. When the acetate is generated metabolically from another substrate, only the low quantum-yield process is observed. These results are consistent with the hypothesis that light is required for the activation of acetate, but that certain compounds (e.g. acetoacetate) can replace this requirement. Additionally, it is proposed that the initial slope of the rate versus light-intensity curve represents the quantum yield for the activation of acetate.

#### PHYSICS SECTION

Chairman: J. Robbins, Hendrix College

P-2-62

Applications of Atmospheric Radioactivity to Meteorological Problems. Paul E. Damon, University of Arkansas.

The necessity of monitoring nuclear explosions has produced a renewed interest in the radioactivity of the atmosphere and hydrosphere. In this case, as in many other cases, a virtue can be made of necessity.

For instance, information of value concerning the following meteorological problems can be obtained:

- (1) The lifetime of charge particles and molecular or atomic ions in the atmosphere
- (2) The function of ions in the condensation and precipitation process
- (3) The mechanism and rate of removal of particulate matter from the atmosphere.
- (4) The migration of air masses and currents and the attaining of atmospheric equilibrium.

P-3-63

The Design and Use of a Cosmic Ray Telescope. C. C. Allen, University of Arkansas.

The operation of a cosmic ray telescope using coincidence Geiger tubes and proportional tubes are described and demonstrated.

P-4-64

A New Condenser Method for Determining Amplitudes of Light Diaphragmatic Materials. Lloyd B. Ham, University of Arkansas.

The exact mode of vibration of light diaphragmatic material is very difficult to determine experimentally since the probe used to make the amplitude measurement increases the load impedance seriously.

Recently, a new condenser method has been devised in which neither side of the condenser is located on the Vibrating diaphragm. The condenser probe consists of a small central disk surrounded by an insulated ring both mounted on the end of a cylindrical piece of bakelite. The terminals for this condenser are connected in parallel with two other condensers associated with the oscillator. The oscillating field for the probe is furnished by use of a very thin plate glued to the diaphragm or by use of sprayed silver paint. The probe is placed about 1 mm distant from the prepared diaphragmatic surface.

An oscillator is designed to operate at 10.7 MC on the Hartley oscillator principle. The two condensers mentioned above are used to adjust the oscillator frequency for a variety of conditions found in the probe. Any oscillation in the tube will cause a slight change in frequency of the oscillator. The frequency-modulated signal is passed through a 6SG7 limiter tube so that a relatively constant amplitude is presented to the discriminator transformer.

The discriminator transformer is designed to transfer equal amplitude signals to each of the plates of the 6H6 tubes at 10.7 MC. There will be no voltage output at this frequency since the output voltages are equal and 180° out of phase.

For a small linear capacity change in the oscillator, there will be both a linear frequency change, and a linear voltage output change. The exact distance between the probe and the tile surface need not be known. After a satisfactory setup is obtained, an experimental calibration of magnitude of change in frequency (*i.e.* amplitude) versus discriminator output voltage may be obtained without knowledge of the exact distance between condenser and diaphragmatic surface.

P-5-65

Reflectivity of Metal Films Deposited at Various Low Pressures. Zabo J. V. Harvalik, University of Arkansas.

It was observed that some metals deposited at certain low pressures form specularly reflecting films, while the same metals deposited at somewhat higher pressure form diffusely reflecting films. When deposition pressures are varied, it was shown that at a distinct pressure the transition from the specularly to diffusely reflecting films occur. This "transition pressure" is typical for each metal.

A correlation of the "transition pressure" and certain physical properties of the metals under investigation will be attempted.

## PSYCHOLOGY SECTION

Chairman: Merrell E. Thompson, University of Arkansas

Ps-1-66

Reminiscence as a Joint Function of Directions and Distribution of Practice. Merrell E. Thompson, University of Arkansas.

PROBLEM: To determine the joint effect of ego-orientation and distribution of practice on performance scores as well as the amount of reminiscence.

POPULATION: Forty male students.

PROCEDURE: The apparatus consisted of a Koerth type pursuit-rotor revolving at 60 r.p.m., two Hunter decade interval timers, and an electric stop clock. The study consisted of a 2 by 2 factorial design as shown below.

Group	N	Instructions	10 Trials		Interpolated		3 Trials	
			Trial	Rest	Rest	Trial	Rest	
1	10	Ego	30 Sec.	5 Sec.	10 Min.	30 Sec.	30 Sec.	
2	10	Ego	30 Sec.	30 Sec.	10 Min.	30 Sec.	30 Sec.	
3	10	Task	30 Sec.	5 Sec.	10 Min.	30 Sec.	30 Sec.	
4	10	Task	30 Sec.	30 Sec.	10 Min.	30 Sec.	30 Sec.	

RESULTS: The results show that the performance of the distributed practice groups is significantly superior to that of the massed practice groups during the original learning period. An analysis of the trials after rest indicates a significant difference for both variables. The two-ego oriented groups showed more reminiscence than the two task-oriented groups and the two massed groups showed more reminiscence than the two distributed groups.

Ps-2-67

The Effect of Time of Exposure to an Anxiety-Arousing Conditioned Stimulus. Robert S. Hicks, University of Arkansas.

PROBLEM: To determine whether or not differential amounts of anxiety result from varying the time during which a subject is detained in the presence of an anxiety-arousing conditioned stimulus.

POPULATION: 12 albino rats, assigned to 3 groups on a rough matched-trio basis in regard to age, sex, and weight.

APPARATUS: The experimental chamber consisted of a black wooden box 14x5x4½ inches, divided into two 7 inch compartments by a barrier 1½ inches high across the center, and with a grid floor wired to deliver shock to the occupant. A drop door on the barrier could be lowered and thus control the exit of the animal from either compartment.

The CS's used were a blinking light and an intermittent tone of 2000 c.p.s. frequency.

PROCEDURE: Each S was given 22 training trials, each consisting of a 9-second presentation of the CS with the US being administered during the last 6 second of this period.

Testing began immediately after the completion of training. Testing involved presenting the CS, and after a varying period of time allowing the animals a means of escape from it by raising the drop door. When the animal crossed the barrier into the opposite compartment, the door was lowered and the CS ceased.

The 0-second delay animals were allowed to escape immediately upon presentation of the CS, while 3-second and 6-second animals were detained for those lengths of time before the drop door was raised.

Fifty test trials were given, with latency values being taken as the measure of response strength.

DATA AND RESULTS: Latencies were combined for each experimental group into 5-trial units, and a single median latency computed.

The Chi-square test for small samples was made to determine the significance of the differences between each 5-trial median latency for the three experimental groups.

It was found that, for trials 1 to 35, between the 0-second and 3-second groups, 4 of the 7 differences were significant at or below the 2.5 per cent level.

For trials 21 to 40, between the 0-second and 6-second groups, 3 of the 4 differences were significant at or below the 2.5 per cent level.

CONCLUSION: Although the evidence from this study is not clear-cut, strong trends have been manifest which indicate that animals detained in the presence of an anxiety-arousing CS may experience an increment of anxiety over those allowed an immediate escape from it.

Ps-3-68

The Medical College Admissions Test Score as a Criterion for Admission to Medical School. Edmond F. Erwin, University of Arkansas.

The Medical College Admissions Test is the official test of the Association of American Medical Colleges for use with applicants to medical school. The purpose of the Medical College Admissions Test is to give the medical college an independent current common index for all of its applicants. This index reflects certain established abilities and aptitudes, and has been used with the idea that success in medical school can be predicted from it.

The evidence from several studies which correlated scores of the Medical College Admissions Test with grades attained in medical school is conflicting. Some have reported a high degree of predictive value, and others have failed to confirm this.

In the present study, scores on the Medical College Admissions Test were correlated with premedical grades, with grades in medical school, and with the results of the National Board examinations. Several classes of medical students were used. Relationships among the various factors are presented, and recommendations for the use of the test are made.

SOCIOLOGY AND ANTHROPOLOGY SECTION

Chairman: Fred W. Voget, University of Arkansas

S-3-72

Land Tenure Process in the Arkansas Coastal Plain. J. L. Charlton, University of Arkansas.

The people who reside on farms in the Arkansas Coastal Plain compete for the operatorship and ownership of the land. They also acquire during working age property in the dwelling and other materials used in family living. An adverse tendency is the low rate of ownership transmission between generations in the stem family. Also unfavorable is the higher rate of migration of owner children than of tenant children, of those who have attended high school, and from families having the more adequate material level of living. Marked rise on the agri-

cultural ladder during the working age of the operator must occur if agriculture is to remain stable and ownership be maintained or increased.

S-4-73

The American Indian in Transition. F. W. Voget, University of Arkansas.

Faced with the realities of conquest and a sense of failure, the American Indian has turned to solutions that may be termed ethico-religious. The characteristic features of these reformative efforts, based on a survey of Plains Indian Peyotism, Northwest Coast Shakerism, and the Iroquoian "Long House" are as follows:

1. A prophetic teaching in which the Creator reveals his abiding interest in the Indian People and seeks to heal them, make them better individuals, and preserve them in the face of the overwhelming power of the European.

2. A rejection of the aboriginal system as a model for the new life, and the adoption of an accommodative and syncretic solution to current problems.

3. A type of ceremony which in form is predominantly "Indian", but which in meaning allows for substantial reinterpretation within the Christian framework.

4. A missionary program designed to spread the new religion to adjacent Indian groups and to unite them into a common religious brotherhood.

5. A new social order that comprises organizational statuses from the dominant American society in association with specific tribal and general "Indian" statuses.

6. A political program designed to achieve religious and civil equality for the Indian within the framework of the dominant society.



## COWPEA AND BEAN WEEVILS

W. D. WYLIE

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Bean and cowpea seed are often rendered worthless by weevils. In Arkansas the cowpea weevil *Callosobruchus maculatus* (F.) and the bean weevil *Acanthoscelides obtectus* (Say) are the insects usually blamable for this damage. The infestations usually originate in the field, but reproduction of the weevil continues in stored seed as long as temperature is sufficiently high until the entire lot of seed is completely without value.

In 1950 and 1951, insecticidal dusts were applied to cowpeas at Clarksville to determine whether infestation in the field could be prevented, and in 1951 and 1952 infestation counts were made on different varieties of cowpeas at Van Buren to determine whether there were varietal differences in susceptibility to infestation. During this period, some rearing work with the cowpea weevil was done at Fayetteville. Dry seeds also were treated with insecticidal dusts to determine their effectiveness in checking an infestation after it was started.

### DURATION OF STAGES

Duration of the immature stages of *C. maculatus* varies with temperature, humidity, and the type of seed in which they develop. At a mean temperature of 80° F, Williams (3) found the developmental period of the immature stages ranged from 27 to 47 days, an average of 32 days. At temperatures around 68° F the author found the duration of the immature stages varied from 29 to 91 days. Records were obtained for a total of 1,180 individuals. Uninfested dry cowpeas were exposed to adults for one day, then held for emergence of adult weevils. Emergence was irregular. More than 80 per cent of the weevils emerged between the 30th and the 55th day, with an average of 40 days required for this group. From the 56th to the 70th day very few weevils emerged. The rate of emergence accelerated at this point, reaching another peak on the 80th day. The reason for this pattern of emergence was not ascertained. It should be noted that the presence of adults over a long period might be useful in helping the species survive unfavorable periods when food was not available. The pattern of emergence should be helpful also in insuring the presence of both sexes at the same time.

Duration of the adult stage varies greatly with temperature. At low temperatures, unmated females may live as long as 69 days while mated females may live 50 days (2). At a mean temperature of 81° F Williams (3) found that unmated females lived a maximum of 13 days while the life span for mated females was 10 days. Duration of the adult stage might be of considerable importance when weevils move out of infested seed to start an infestation in the field.

The factors which affect oviposition by adult weevils have been studied by a number of investigators. Williams (3) found that females having access to several dry peas deposited significantly more eggs than those exposed to only one pea. He also found that more eggs were deposited when peas were available every day than when they were available only every other day. The availability of water to the females did not appreciably affect the number of eggs deposited, according to Williams (3), although Larson and Fisher (1) obtained almost twice as many eggs when water was available.

Practically no oviposition occurs on pods of ripe or roasting-ear cowpeas when dry pods also are available. This was determined by caging pairs of weevils in the laboratory with both kinds of peas available, and recording oviposition throughout the life of the females. However, females, confined to ripe pods only deposited as many eggs as did another series on dry pods. The number of eggs deposited on ripe shelled peas also was very small when dry shelled peas were available. These data are shown in Table 1.

Different varieties of cowpeas vary considerably in attractiveness to weevils as a place for oviposition. The number of eggs on ripe and the number on dry peas was recorded for several varieties at Van Buren in 1951. Puffy-pod, with 64 per cent of the pods infested, was the most susceptible, while Cream-10, with 7 per cent, showed the lowest infestation. The following year some of the

same varieties were included in counts of the number of eggs found on a 25-pea sample. The same varieties that had a high percentage of the pods infested tended to have the largest number of eggs per sample. Infested samples were held both years for emergence of adults. Those varieties having the heavier infestations also gave rise to the largest number of weevils. The data on infestation of different varieties are shown in Table 2.

In general, there did not appear to be any difference in susceptibility to infestations of cowpeas that could be related to type. The one exception was that the cream peas showed the least infestation. It is sometimes believed that purple-hull peas are less likely to be injured by weevils than are other varieties. In these observations, purple-hull peas were similar to most other varieties both in susceptibility to infestation and to injury. In practically all varieties the amount of injury appeared to be closely associated with the extent of infestation.

Infestation of cowpeas in the field was not entirely eliminated by the application of insecticidal dusts in the experiments of either 1950 or 1951. The dusts were applied with a hand duster, using approximately 20 pounds to the acre. All the ripe and dry peas were removed from the vines before the dusts were applied, then samples of peas were collected at intervals and held to determine emergence of adult weevils therefrom. Two applications of dust were made in 1950, but the plots in 1951 received only one application. In 1951, infested dry peas were placed in the center of the plots as a source of infestation. The insecticides used and the number of adult weevils emerging from the pea samples are shown in Tables 3 and 4.

The severity of infestation in the check plots undoubtedly was reduced by the use of insecticides. This is indicated by the fact that only half as many adults were obtained from samples taken from the check plots after two dust applications as had been obtained after one application. However, none of the insecticides entirely eliminated the infestation. As the samples taken three days after the second dust applications were infested, it appears unlikely that a complete kill of adult weevils present was accomplished.

In 1950 the source of adult weevils was unknown, but presumably it was some distance from the treated area. During the 1951 experiment adults continued to emerge from the infested peas placed in the middle of the plot layout. Each treatment was applied to two plots. The proximity of the plots to the source of weevils appeared to be a much more important factor in determining the extent of infestation than was the insecticide used. None of the plots were located more than 75 yards from the source of infestation.

Exposure to high temperature has been recommended as a control measure for a variety of insects. A temperature of 130° F for three hours is generally considered to be lethal to insects in stored grains. Beans infested with bean weevil and cowpeas infested with cowpea weevil were exposed at 130° F for three hours in small lots in an electric oven where the variation in temperature was plus/minus one degree. Samples thus treated were held for emergence of adult weevils. No emergence occurred from the cowpeas. Several bean weevils emerged from the bean samples. These weevils were given access to beans, and a few eggs were deposited by them.

Insecticidal dusts have been applied successfully to beans and cowpeas as well as to other types of seeds to protect them from insect damage. This type of control has several advantages over the use of fumigants. Probably the most important advantages are that no special tight containers are required, and the danger of immediate reinfestation is not nearly so great. Ordinarily, infestation present at the time seed is harvested is so light that little harm will be done, providing another generation of weevils can be prevented. A coating of insecticide does this successfully by killing adults by contact before they can deposit eggs.

#### SUMMARY

Cowpea and bean weevils often completely destroy cowpea and bean seed in storage. Infestation originates in the field before harvest. When a number of varieties are present in a field, some varieties are much more heavily infested

than others. Insecticidal dusts applied in the field did not give satisfactory control of weevils. When dry seed were treated with an insecticide prior to storage, weevils were effectively controlled.

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Table I. Number of eggs deposited by cowpea weevil when given a choice of oviposition sites.

Oviposition site	Number eggs
{ Dry pods	126.0}
{ Green pods *	1.5}
{ Dry peas	113.0}
{ Green peas *	9.0}
{ Dry peas	112.0}
{ Green pods *	2.0}
Green peas *	71.0
Dry peas	66.0
Green pods	67.0

(\*) These were at stage of maturity for eating as ripe fresh cowpeas.

Table II. Varietal differences in susceptibility to infestation by cowpea weevil at Van Buren, Arkansas, 1951-1952.

Variety	Per cent 1951 Infested	Number eggs per pod 1952
Puffy-Pod	64.3	2.27
California Blackeye No. 5	48.1	
Brown-Sugar Crowder	45.4	3.04
Purple-Hill 49	39.0	1.27
Blue Goose	33.3	
Calva-No. 3 Blackeye	31.2	1.03
Ramshorn Blackeye	31.0	2.41
Red-speckled Crowder	25.9	
Conch Early-Bunch	22.9	
Calhoun Crowder	19.4	0.68
Cream-40	16.1	0.60
Cream-14	8.7	
Cream-10	7.1	

Table III. Number of adult weevils bred from cowpeas harvested from plots dusted with different insecticides in 1950.

<u>Treatment</u>	<u>Dusted Once</u>	<u>Dusted Twice</u>
Check	150	75
DDT	79	10
Methoxychlor	117	31
Chlordane	76	20

Table IV. Number of adult weevils bred from cowpeas harvested from plots dusted with different insecticides in 1951.

<u>Treatment</u>	<u>Number Adults</u>
Check	53
Aldrin	39
DDT	78
Toxaphene	56

Table V. Percentage of dry seed damaged by weevils after treatment with insecticides.

<u>Material</u>	<u>Dosage</u>	<u>Peas</u>	<u>Beans</u>
g-BHC	1-50,000	0	0
	1-200,000	0	0
	1-1,000,000	0	0
	1-4,000,000	0	-
DDT	1-2,500	0	0
	1-10,000	0	0
	1-25,000	0	0
	1-75,000	0	0
Arasan	-	25	0
Check	-	100	100

CATIONIC ACTIVITIES AND THE EXCHANGE PHENOMENA  
OF PLANT ROOTS  
RELATIONSHIP TO PRACTICAL PROBLEMS OF NUTRIENT UPTAKE<sup>1</sup>

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The feasibility of measuring cationic activities in systems of plant roots was indicated in a preliminary report on this general subject (4). The energy with which a cation is bonded to the exchange seats of the root surface can then be computed from the cationic activities. The present study has been conducted in an attempt to find whether these mean that free-bonding energies have any significance in practical problems involving nutrient uptake.

Some plants utilize Na as a partial replacement for K needs. Such plants accumulate large amounts of Na. Other plants do not absorb Na to any appreciable extent. It seemed worthwhile to determine whether the ability to accumulate Na by a plant would be reflected in the relative bonding energies of plant roots for Na.

The maintenance of grass/legume pastures and meadows has become a difficult task because of diversity of nutrient requirements by the grass as compared to the legume. Some work has indicated that the relative cationic exchange capacities of the roots of the different species was important in this problem (1), hence it seemed likely that the mean free-bonding energies of the cations to the roots might be important also.

The diverse ability of different plants to utilize phosphorus from insoluble sources such as rock phosphate has long perplexed agronomists. Could it be that the plants' ability to break up the tricalcium phosphate molecule in rock phosphate is related to the ability of the roots to bond calcium?

EXPERIMENTAL

Since the previous report in this series, the determination of cationic activities and mean free-bonding energies for various cations has been extended from soybean and alfalfa roots to those of Reed canary grass, red top, lespedeza, corn, oats, and another variety of alfalfa. The plants were grown in level cultures of 1/5 Hoagland's solution as has been described (4) (5). The plants were grown for various lengths of time as follows: Cereals, 15 days; legumes, 30 days; and grasses, 50 days. The procedure for determination of cation activities was exactly as previously described. The uptake of Na by several plants is being determined by replacing with NaO, 1/4, 1/2 and 3/4 of the K in the 1/5 Hoagland solution and growing the plants in quadruplicate in No.2 tin cans of gravel bathed with these solutions.

In other studies reported elsewhere (6), the uptake of phosphorus from soil treated with various phosphates by several of these same plant species was determined.

DISCUSSION OF RESULTS

As these studies are still in progress, the results reported in tables 1, 2 and 3 are in some cases incomplete. However, it is believed that sufficient progress has been attained to justify inclusion here. It appears from the data of Table 1 that some relationship does exist between the tendency to take up Na and the bonding energy of Na to the plant root; however, there is need for completion of two key determinations before definite conclusions can be drawn.

<sup>1</sup> Research paper No. 0000 Journal Series, University of Arkansas, Fayetteville, Arkansas. Published with permission of the Director of the Ark. Agr. Exp. Sta. A major part of this work has been and is being submitted by the junior author as partial fulfillment of the requirements for the M. S. Degree in the Graduate School, University of Arkansas. This investigation was largely supported by a grant from the Mathieson Chemical Corporation, and this support is gratefully acknowledged.

<sup>2</sup> Associate Professor, Graduate Assistant and former Graduate Assistant, respectively.

Table 1. Mean Free-Bonding Energies of Plant Roots for Na in relation to Na Uptake by These Different Plants.

Plant	$\Delta F_{Na}$ (Calories/mole)	Tendency to take up Sodium*
Corn	0	nil
Reed canary grass	55	↑
Oats	559	Moderate
Alfalfa	599	Moderate
Celery	†	Excessive

\* As recently reported in Soil Sci., 76:1 (1953)

† Values being determined but not yet available.

Table 2. Mean Free-Bonding Energies of Legume and Grass Roots for Ca and K in Relation to Their Relative Competition for These Cations.

Plant	$\Delta F$ (Calories/equivalent)		$\frac{\Delta F_{Ca}}{\Delta F_K}$	Cation for which Competition is Keenest
	Calcium	Potassium		
<b>Legumes:</b>				
Alfalfa (K.C.)	775	672	1.16	Calcium
Alfalfa (B.)	590	642	0.92	Calcium
Soybean	827	711	1.16	Calcium
Lespedeza	815	705	1.16	Calcium
<b>Grasses:</b>				
Red Top	509	861	0.59	Potassium
Reed Canary Grass	329	648	0.51	Potassium

The data of Table 2 appear to give excellent support to the work of Gray, et al (3). They showed that certain grasses are so competitive with clovers grown with them that it is near impossible to maintain sufficient K in the soil to meet the needs of the clover. The relatively high values of the  $F_{Ca}/F_K$  ratio for the legumes and the relatively low values for the grasses would seem to offer some explanation as to why legumes tend to accumulate Ca while the grasses tend to accumulate K even to the detriment of the legumes.

Evidently there is a definite relationship between the ability of a plant to utilize phosphorus from rock phosphate and the relatively high mean free-bonding energy of the roots for Ca (Table 3). Graham (2) showed that the free energy change in the exchange of Ca for H on various colloids correlated with the abilities of the acid colloids to weather rock phosphate and render phosphorus available to a test crop. This might suggest that the ability of buckwheat and similar crops to utilize phosphates of low solubility may be related to this relatively high mean free-bonding energy for Ca. Perhaps the latter is a formidable weathering force in attacking rock phosphate much in excess of that of certain other types of plant roots. Truog (7) indicated many years ago that plants' abilities to take phosphorus from low solubility materials was related to their calcium content in the tissues.

Table 3. The Mean Free Bonding Energy Ratios as Indices for Determining the Ability of a Plant to Utilize Rock Phosphate.

Plant	$\frac{\Delta F_{Ca}}{\Delta F_K}$	Ability to Utilize Rock Phosphate*
Buckwheat	1.67	High
Alfalfa	1.16	Moderate
Soybean	1.16	Moderate
Lespedeza	1.16	Moderate
Red Top	0.59	Low
Reed Canary Grass	0.51	Low

\* In part based on studies reported (6) and in part based on general knowledge of the relative abilities of these crops to utilize rock phosphate.

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## THE HOUSE-FLY PROBLEM

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It is significant that in 1954, the 100th anniversary of professional entomology in the United States, the house fly, one of man's oldest insect enemies, still is a major problem. This emphasizes the remarkable ability of insects to survive by adapting themselves to drastic changes in environment.

### HISTORY AND IMPORTANCE

House flies have been a part of human environment in all periods of recorded history (Exodus 8:23) (17). Ancient peoples undoubtedly accepted them and merely brushed them aside. During colonial times there was a general feeling of tolerance toward the house fly, and this attitude still persists among some people even today.

The house fly was first associated with disease as early as 1577 (4), and attention was called to the spread of gangrene by flies during the Civil War (5). With the experience of the American troops in the Spanish-American war and the British troops in the South African war, there came a period of incrimination. Between 1910 and 1915 there was a period of popular education which resulted in better sanitary conditions. During World War II the necessity for combating filth-borne diseases was again brought into focus, and in areas of hostilities insecticidal sprays, mostly DDT, were the principal tool. This development ushered in a new era, and immediately following the war many people believed that man's battle against the house fly was at an end. Such was not the case.

### LIFE AND SEASONAL HISTORY

Recent research shows that continuous breeding (10) as far north as New York is an important means by which the house fly survives the winter. Activity begins at about 44° F, and the optimum is 91° F (11). Thus the seasonal cycle is closely associated with the rising temperature in the spring and falling temperature in the fall. In temperate zones, near optimum temperatures prevail for long periods.

Incubation of the egg may require 24 hours or less; first-stage larvae may molt in another 24 hours; about the same time is spent in the second stage; and third-stage larvae take from three to nine days to transform to pupae. The pupal period may be as short as three days. Thus the minimum cycle is about eight days (17). Adults may live as long as 91 days at 60° F.

An adult female is capable of laying four to six masses of eggs averaging 120 eggs each. Devoe (2) has estimated at from 325,923 to 200,000,000 the number of summer descendants which may result from a single mated pair.

Larval food is as diverse as the materials on which oviposition occurs. There is no record of eggs being deposited on a substance which will supply no nourishment to the larvae. Animal excrements (3) are the preferred larval food, with animal wastes and pen litter next in choice. Pig dung is preferred over horse and cow dung. Chicken manure is suitable only when moist.

The flight range of the adult may be as great as 20 miles (19). This ability, coupled with a short life cycle and an enormous reproductive capacity, makes it possible for flies to disperse over wide areas in a very short time. Such a general dispersion is unusual, however, as attractive feeding and oviposition sites near the place of emergence are numerous.

### CONTROL

Control may logically be divided into two functions: prevention of larval development, and control of adult populations.

### PREVENTION

Sanitation is the principal means of combating the house fly outside of buildings, and aids materially in reducing the number of flies inside. On farms animal manures are the principal sites of breeding and if allowed to accumulate



for eight days can produce a generation of flies. Larval development can effectively be prevented by removing the manure twice weekly and scattering it over fields, or it may be stored in vertical-sided manure pits and treated.

Borax in the ratio of 11 ounces to 8 bushels of manure is an effective manure treatment, but may be injurious to crops if used in excess. A combination of calcium cyanamid and superphosphate, using one-half pound of each to a bushel of manure, gives almost complete control of fly breeding. These chemicals also add nitrogen and phosphorous to the manure.

#### CONTROL OF ADULT POPULATIONS

Screening of windows and doors provides an effective barrier to the entrance of flies, but some always manage to gain entrance. The old fly swatter is still a useful tool for killing a few flies inside homes. If the flies are numerous, fly traps, fly papers, electrocutors, poison baits, or insecticidal sprays may become necessary.

Prior to the development of DDT, pyrethrum in refined kerosene was the principal insecticide used. As a space spray this was applied with a small plunger-type hand sprayer. It is effective only against those flies contacted at the time of application.

DDT, because of its residual properties, provided a method that was effective for a long period of time. It was so effective that scarcely a fly was seen during some seasons (6) and some authorities thought that this was the final answer to house-fly control. Its dramatic effectiveness was to some degree responsible for a general relaxation of sanitation practices that formerly had been the primary weapon against flies.

#### RESISTANCE

The miraculous control of the house fly was short because resistance to DDT soon developed. Resistance was first reported in 1947 from Italy (16), and since that time has been recorded in all areas of the world. Flies resistant to DDT also exhibited initial resistance to the other chlorinated hydrocarbons, even though they had not been exposed to them. Resistance soon reached a level where the amount of material required for satisfactory kill exceeded practical limits. Until late summer of 1953 there was no satisfactory material for residual application.

Many proposals have been put forth in an effort to explain resistance (6, 14, 18) none of which can account for all details. The most logical explanation is on the basis of population genetics. Killing all the susceptible flies results in a concentration of flies having the factor for resistance. This explanation is substantiated by the fact that with some laboratory cultures resistance could not be established by exposure to sub-lethal concentrations, thus demonstrating that resistance is not an "acquired" characteristic in the strict sense of the word (1).

While it is generally conceded that genetic factors are responsible for the development of resistance, it is still necessary to understand why the insecticide is no longer toxic to the fly. Physiological experiments have shown that flies can detoxify DDT to non-toxic DDA and DDE. There are some discrepancies (12). Further studies also show a difference in the amount of cytochrome oxidase, an enzyme important in the final steps of oxidative metabolism (13, 15).

Recent evidence indicates that resistance is eventually lost (8). The practical value of this fact is not yet evident, but it may mean that infrequent use of the chlorinated hydrocarbon insecticides may be permissible.

#### CONTROL OF RESISTANT FLIES

The need for control of resistant flies has been, and is still to some degree, one of the most pressing entomological problems of recent years. Materials exhibiting synergistic effects with DDT and other similar compounds were thoroughly investigated (9). Such combinations were effective for a short time only, as resistance to them developed also. More recently (7) DDT-resistant flies have not been able to become resistant to the organic phosphate compounds such as TEPP, parathion or malathion. Some slight resistance, up to seven fold, has been noted, but no further resistance developed after 26 additional generations. This is within practical limits.

As resistance to the organic phosphates is of a low degree and will not increase, considerable effort has been made to develop methods of application suitable for using these compounds. Parathion-impregnated twine, liquid-TEPP bait, dry-sugar baits with Bayer L 13/59, and others which are considered either too toxic to mammals to be applied as a residual treatment, or which are lacking residual properties, have been tested.

Several newer compounds, all organic phosphates, are receiving experimental trial. Some are showing excellent promise and may be the practical answer to resistance and satisfactory control. The residual properties, while not as good as DDT was in the early days, are much better than that of compounds currently recommended. Some of these compounds are diazinon, chlorothion, L 23/59, and L 21/199.

#### RECOMMENDATION

Sanitation is, as it always has been, the method of first importance in fly control. Direct control measures are supplementary only. Malathion in the proportion of 2 gallons of 50 per cent concentrate plus 12 to 20 pounds of sugar is currently recommended as a residual treatment, except in dwellings. Screening, pyrethrum space sprays, and swatting should not be overlooked as a means of combating the fly in the home.

#### SUMMARY

The house fly, because of its world-wide distribution and its close association with man and filth-borne diseases, presents a problem of importance to everyone. Its short life cycle, high fecundity, long flight range, and its ability to develop in a wide assortment of media makes it a difficult pest to control. Residual DDT application gave near-perfect control until the flies became resistant. However, the development of resistance re-emphasized the necessity for a return to sanitation measures which always will remain the first line of defense against the house fly.

Recent experimental work indicates that a high degree of resistance is never developed when the flies are exposed to the organic phosphates. This offers some hope that a satisfactory method of direct control will be developed.

Direct control measures should be considered supplementary to sanitation. New methods such as insecticide-impregnated twine, liquid baits, and dry-sugar baits may be useful in certain situations, and the old fly swatter remains a useful and important implement of house-fly control.

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## LABORATORY OR BUSYWORK?

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Louis Agassiz is usually credited with the introduction of the laboratory method into American education, and its use, like so many innovations in science, has spread widely and extensively into other fields so that we now have laboratories in the social sciences, arts, and other disciplines. At the time of its debut into science education, the laboratory provided an invigorating stimulus to the student which has been reflected in scientific progress down to our present time. With the introduction of the laboratory, the student, for the first time, was presented with tools and an avenue of escape from the "bookish" instructional tradition inherited from the Middle Ages.

The laboratory can be and still is a stimulating and meaningful method of instruction, but it must be admitted that it has too often deteriorated into an end in itself rather than a means to an end. All of us can recall courses from our undergraduate and graduate days in which the laboratories were insufferably boring to the end that their value was dissipated and lost. Have we, then, forgotten the prime reasons for using the laboratory? The author does not think so, but a restatement would not be out of order.

The laboratory offers the instructor in the biological sciences, particularly in the more descriptive aspects, unparalleled opportunity to introduce the student to a mass of material from which he may, with proper guidance, derive basic concepts and principles which otherwise would have scant significance or meaning. There is no other method by which taxonomy, anatomy, morphology, and physiology may be taught and made significant to the student. He must see, feel, examine, rearrange, and manipulate this material in order that the ideas and concepts presented in lecture and text may come alive and assume a significant pattern in his personal experience, providing foundation for further enlargement of his intellectual horizon. The student may, and we say may, also experience to some degree the spirit of those who have formulated the basic theories and principles prevalent in modern science by attempting to duplicate some of the effort and procedure which gave rise to those conclusions. It would appear that the physical sciences have advantages over the biological in this respect. And, finally, we often claim that laboratory is to teach technique and to create desirable research habits.

How well do we achieve these aims, and if we fail, why? An examination of our own efforts may be rewarding and, at the same time, point out means by which we may make the desired correlations and establish the desired habits and techniques.

The science instructor today may be confronted with several problems: large classes, insufficient time, inadequate equipment, inadequate secondary preparation of the student, and sometimes undesirable physical facilities. Also, our store of scientific knowledge has mushroomed and expanded to a bewildering and almost discouraging extent and depth. It is not the purpose of this paper to propose remedies or to apologize for conditions as they exist. Certainly anything which may alleviate them is to be condoned and encouraged. The objective is, however, to examine present practices and determine if we are using our laboratories most efficiently and effectively under conditions which we are forced to accept.

As is true for any teaching situation, the laboratory requires careful planning and preparation, otherwise it degenerates into a stultifying routine. Administrative authorities should be aware of this and make adequate adjustments in the teaching load and schedule of the instructor. At the same time, the instructor is under the ethical obligation to use whatever time resources and allowances are placed at his disposal. While an overloaded instructor may be pardoned for the administrative sins of his superiors, no excuse exists for failure to do some planning for the laboratory period.

Regardless of the methods employed, one must first determine what objectives are to be met by the laboratory, and then how much information is to be imparted

or material covered. Here again the vast quantity of material now available in any area of science renders it imperative that the instructor determine beforehand what will be covered and how much of that relegated to the laboratory period.

In connection with the conservation of time, it is the writer's opinion that the demonstration method has hardly been employed to the full extent of its usefulness. Surely each individual here can recall pertinent examples from his specialty which, if presented as a demonstration, would more adequately correlate observation with lecture material and save time which could more profitably be employed on other laboratory work. These same experiments or observations, if left to the student, are often time consuming and have little end value. The chemist faces the problem of equating and ever-expanding quantity of information with a rather fixed length of time in which to do it. This is especially true in those courses of a general nature which any field of science may have to offer. One effort to solve the problem in chemistry has been to increase the laboratory period from two to four hours. In general, this may not be effective as it simply gives the student more time in which to stand around and wonder more and understand less about what he is doing. An overly-long laboratory period is robbed of much of its effectiveness by the increasing factor of fatigue. This criticism could be made of any field of science. It is, therefore, encouraging to learn that some institutions are again adopting the two-hour laboratory period, and that a more adequate use of the demonstration method is contemplated here in our own state.

No matter how long the laboratory period, it is well that the students be briefed on general procedure, material available, and the pertinent points to be kept in mind while working. Students are students. We should accept the fact that they are, and that they forget in varying degree whatever instructions may have been given them in lecture prior to the laboratory period. However, there is a danger to be avoided here. The instructor may be too solicitous, with the result that the student fails to develop any confidence in his ability to work on his own, and exhausts the teacher by asking for decisions which he and not the instructor should make. If the briefing is adequate, this sort of thing should be eliminated, provided the teacher has correctly judged his class. There is, unfortunately, no set formula for adjusting briefing to a class, but the experienced instructor can usually handle the problem. After all, teaching is an art as well as a science.

Development of a feeling of self-reliance in the student and his ability to work on his own are generally agreed to be legitimate objectives of laboratory instruction. We should not, however, overemphasize this aspect as we also are under the obligation to develop in the student the ability to work as a member of a team. This is all the more important for our advanced students who have decided on a career in science and who may be called upon for research. Since modern research is tending more and more toward the team effort, we are obligated to recognize this need. It can be achieved to some extent by organizing students into small groups and insisting that the members of the group work out their problems, and that the group exchange ideas with other groups.

Because we recognize the necessity for developing individual initiative, we should beware of the danger inherent in a laboratory program which constantly overloads the student so that he is always behind. This is psychologically disruptive in that the student develops a feeling of never achieving any mastery of the subject matter. Provisions should be made for a few laboratory periods which the student might be able to complete a few minutes early. It appears to the writer that there is some merit in this procedure in that it would give the student a sense of accomplishment. Of course, the student must always feel the necessity for working or he becomes intellectually indolent. But the "push" can and has been overdone.

And finally, what are we doing in this matter of equipment? Everyone realizes that, depending on the course and science, there is a minimum amount of equipment necessary for laboratory work. If this minimum is not available, the laboratory would be better abandoned and the course accepted for what it can only be under the circumstances -- a book course -- and taught accordingly. There is nothing more demoralizing to the student than subjection to a laboratory regimen which tries to achieve certain ends, yet has not the means wherewith to do

so. At the same time we must realize that an elaborately equipped laboratory can be the source and scene of educational malpractice. Many would agree that today we have too much instrument manipulation and not enough thinking. We should be certain that we are resourcefully using what equipment we have available before becoming involved with an array of gadgets.

The writer does not have the audacity to claim originality for the ideas and comments expressed. Of a certainty all present are already aware of what has been said. But is it not true that we often forget the proper use of the laboratory and permit it to become an end in itself? We have laboratory because a science course just naturally has to have a laboratory to be a science course. We constantly need to reexamine our employment of this teaching device so that it may contribute to that which is most essential: the education of the student.

AN ANNUAL TEMPERATURE STUDY OF FIVE  
NORTHWEST ARKANSAS LAKES

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Temperature records taken over a period of fifteen years from lakes in northwestern Arkansas show that lakes in this region normally differ from typically stratified lakes of the temperate zone in that they do not go through a winter stagnation period. Between the years 1938 and 1953 only one instance of freezing over was found; in 1940 the lakes of this region were covered with a thin coating of ice during the first week in January. In recent years a number of investigators have published reports on thermal conditions for lakes in southwestern United States. Some of these publications are: Harris and Silvey (1940) and Cheatum, Longnecker, and Metler (1942) for Texas; Moore (1950) for Louisiana; Irwin (1941) and Wallen (1951) for Oklahoma; and Hoffman (1951, 1952) for Arkansas. All of these investigators report thermal stratification in summer; and those which dealt with annual temperature studies show one continuous circulation period throughout the winter.

During the years 1949 and 1950 vertical series of temperatures were taken, using a Negretti and Zambra reversing thermometer, from five artificial lakes in northwestern Arkansas. These temperature records are presented here so that they may be compared with published accounts taken from lakes in neighboring states and from other areas. The five lakes studied ranged in depth from 5 to 20 meters, in area from 50 to 525.5 acres, and were located within a radius of 40 miles of Fayetteville, Arkansas (Table 1).

Table 1. General Data for Lakes.

Lake	Impounded	Maximum Depth in meters	Surface area in acres	Exposure to wind action
Fort Smith	1936	20	525.5	Moderate
Wedington	1937	12	81.5	Moderate
Atalanta	1937	11	77.0	Slight
Fayetteville	1950	12	170.0	Great
Hindsville	1950	5	50.0	Slight

STRATIFICATION PERIOD

Vertical series of temperature readings taken from five Northwest Arkansas lakes between July 1949 and June 1950 are presented in Table 2. In this table the extent of the thermocline is indicated by numerals in italics, and a sudden drop in temperature between two adjacent meter levels is indicated by an underscore. Birge's rule, i. e., a temperature drop of 1.0 °C or more per meter (Welch, 1952), was used to select the thermocline limits.

Table 2 shows that the five lakes were already stratified in July, 1949, when this investigation was begun, and all but two remained in this thermal state through October. Two lakes, Atalanta and Fayetteville, had no thermoclines in October, but a temperature gradient existed between the surface and the bottom levels. Chemical records taken during this time, but not presented in this paper, indicate that even though no thermoclines were present in Lakes Atalanta and Fayetteville during October 1949, chemical stagnation conditions still prevailed at the lower levels.

In the spring of 1950 all lakes showed stratification by the first week in May. The temperature of the water near the bottom when stratification was first recorded ranged from 10.8°C to 12.0°C. No definite stratification pattern was found as to thickness and position of thermoclines between spring and middle

Table 2. Vertical series of temperature readings for five Northwest Arkansas lakes from July, 1949 to June, 1950.

		LAKE ATALANTA, BENTON COUNTY, ARKANSAS																		
Depth in Meters		Dates of Sampling																		
		7/5	7/21	8/1	8/14	9/24	10/9	10/24	11/7	11/26	12/12	1/6	2/17	3/2	3/29	4/10	4/24	5/8	5/23	6/18
1		<u>26.4</u>	<u>22.8</u>	24.3	<u>23.0</u>	20.1	18.5	18.3	15.0	8.2	5.0	4.2	4.6	10.6	11.4	11.0	14.3	18.6	23.7	21.0
2		24.0	21.0	23.1	19.3	19.4	18.2	18.0	14.8	--	--	--	--	--	--	--	--	18.6	22.9	20.8
3		24.0	20.4	20.1	18.9	19.0	17.8	17.6	14.8	--	--	--	--	--	--	--	--	18.6	20.0	18.4
4		16.4	19.4	19.2	18.4	18.5	17.1	17.4	14.8	--	--	--	--	10.4	--	--	--	18.0	18.7	17.5*
5		15.6	17.0	17.1	18.2	17.8	16.8	16.5	14.8	8.2	4.7	4.2	4.6	8.0	11.4	10.9	<u>14.2</u>	16.2	16.8	16.7
6		14.5	15.8	15.6	16.7	16.5	16.2	15.6	14.8	--	--	--	--	7.0	10.6	--	12.6	14.3	14.6	15.0
7		14.2	14.8	14.7	15.9*	15.3	15.5	15.0	14.7	--	--	--	--	6.4	9.7	--	11.8	12.4	13.3	13.8
8		14.1	14.2	14.1	14.3	14.7	15.0	14.7	14.6	--	--	--	--	6.4	--	10.5	11.5	11.4	11.9	13.0
9		--	13.9	13.7	14.3	14.5	14.6	14.7	14.5	--	--	--	--	6.2	--	9.8	--	11.0	--	12.7
10		--	--	13.6	14.3	14.3	14.2	14.2	--	8.2	4.7	4.2	4.6	6.0	9.4	9.5	10.8	10.9	11.5	12.6

		LAKE WEDINGTON, WASHINGTON COUNTY, ARKANSAS															
Depth in Meters		Dates of Sampling															
		7/24	8/2	8/16	9/25	10/9	10/23	11/6	11/27	12/18	1/12	2/21	3/17	4/1	4/13	5/4	6/1
1		26.0	26.4	27.8	22.8	20.7	18.8	15.0	8.8	4.6	4.2	4.6	8.4	11.4	10.1	20.8	25.6
2		25.6	26.2	27.7	22.6	20.0	18.8	14.7	8.8	4.6	--	--	--	11.3	--	--	25.4
3		25.0	25.8	27.6	22.4	19.2	18.6	14.7	8.8	4.6	4.0	4.4	--	11.2	10.1	20.4	25.1
4		22.0	22.3	24.0	22.2	19.1	18.4	14.7	8.7	4.6	--	--	--	11.2	--	14.9	23.4
5		17.7	19.2	20.3	22.0	19.0	18.4	14.7	8.7	4.6	4.0	4.4	8.2	11.2	10.1	13.4	23.0
6		15.2	15.4	16.4	18.9	18.0	18.4	14.7	8.7	4.6	--	--	8.2	11.2	--	12.4	19.6
7		14.6	14.2	14.5	15.0	16.4	18.4	14.6	8.7	4.6	4.0	4.4	8.2	11.2	10.1	11.2	19.2
8		13.7	13.4	13.4	13.7	14.4	14.6	14.5	--	4.6	--	--	7.8	11.2	--	--	16.6
9		13.6	12.9	12.9	13.7	13.6	13.4	14.4	--	4.6	--	--	--	11.2	--	11.2	11.2
10		13.6	12.8	12.4	--	--	13.4	14.4	7.9	4.6	4.0	4.4	7.6	11.2	10.1	11.2	11.2



LAKE HINDSVILLE, MADISON COUNTY, ARKANSAS

Depth in Meters	Dates of Sampling														
	7/13	8/11	9/28	10/16	10/31	11/10	12/11	2/23	3/15	3/30	4/12	4/30	5/17	5/30	6/22
1	25.6	26.2	<u>23.2</u>	20.4	20.8	12.6	4.5	10.2	6.5	10.4	9.2	19.6	22.2	23.7	27.2
2	22.8	22.7	21.3	19.4	20.1	12.6	4.5	8.8	6.1	9.8	9.2	18.6	21.8	22.8	25.2
3	19.0	21.7	21.1	18.4	18.9	12.6	4.5	5.8	6.0	<u>9.1</u>	9.2	15.7	18.5	20.5	22.2
4	15.1	20.7	20.6	18.1	17.8	12.6	4.5	5.8	5.9	7.8	9.2	11.8	14.2	19.5	19.7
5	15.1	20.0	19.6	17.5	17.8	12.5	4.5	5.2	5.8	7.4	9.2	10.8	11.2	14.8	16.0

LAKE FAYETTEVILLE, WASHINGTON COUNTY, ARKANSAS

Depth in Meters	Dates of Sampling																	
	7/7	7/26	8/7	8/14	9/26	10/12	10/30	11.9	11/28	12/14	1/11	2/23	3/17	4/9	4/23	5/7	5/24	6/23
1	26.6	25.0	23.8	28.7	21.5	<u>19.9</u>	19.7	13.7	7.6	3.5	3.1	9.0	6.6	11.0	14.4	<u>21.3</u>	23.0	26.2
2	26.6	24.0	23.4	24.6	21.3	18.8	19.6	-	-	-	-	8.8	-	-	-	19.1	23.0	24.8
3	25.2	22.2	21.4	23.1	20.8	18.6	19.4	-	-	-	3.4	-	-	-	13.6	18.7	23.0	21.9
4	22.0	22.2	20.4	21.0	20.5	18.5	18.6	-	-	-	-	-	-	-	-	18.3	21.2	18.0
5	18.2	22.2	19.5*	19.4	19.8	18.3	18.4	13.7	6.8	4.0	-	8.0	6.5	11.0	13.3	15.8	18.2	17.4
6	16.0	18.1	17.8	18.3	18.8	17.9	18.2	-	-	-	-	-	-	-	-	14.0	16.0	<u>16.6</u>
7	15.8	17.2*	17.0	17.4	18.0	17.7	18.1	-	-	-	3.7	-	6.5	-	12.7	13.3	14.8	15.6
8	15.8	16.2	16.9	17.0	17.6	17.5	17.9	-	-	-	-	8.0	-	-	12.0	22.8	13.4	15.6
9	15.2	16.0	16.4	16.6	17.3	17.4	17.5	-	6.6	4.0	-	-	-	-	10.8	12.0	13.0	15.4
10	-	15.6	16.6	16.4	17.0	17.2	17.4	13.7	-	-	-	7.3	6.5	11.0	10.8	12.0	12.5	-

## LAKE FORT SMITH, CRAWFORD COUNTY, ARKANSAS \*\*

Depth in Meters	Dates of Sampling																	
	7/12	7/19	8/9	9/23	10/7	10/22	11/4	11/25	12/9	1/6	2/24	3/11	4/1	4/20	5/5	5/19	6/12	
1	25.6	25.3	25.8	23.1	20.4	19.4	17.2	10.8	7.0	5.0	10.0	11.2	10.8	14.4	18.4	20.8	26.2	
2	25.6	25.2	25.2	23.0	20.4	19.4	--	--	--	--	--	--	--	14.2	--	20.8	23.4	
3	25.6	25.2	23.6	23.0	20.4	19.4	--	--	--	--	--	--	--	13.5	18.4	20.8	21.4	
4	25.1	25.0	22.5	23.0	20.4	19.4	--	--	7.0	5.0	--	--	--	12.6	17.2	20.4	19.6	
5	<i>20.0</i>	<i>23.8</i>	21.6	<u>22.8</u>	20.4	19.4	17.4	10.8	--	--	9.8	11.2	10.8	11.9	<i>15.8</i>	<i>17.8</i>	16.8	
6	<i>17.0</i>	20.8	21.4	21.0	20.4	19.4	--	--	--	--	--	11.2	--	--	<i>14.8</i>	<i>14.8</i>	16.6	
7	15.6	19.8	20.9	20.2	<u>20.3</u>	19.2	--	--	--	--	8.6	11.2	10.7	--	12.7	13.4	15.8	
8	15.4	<i>17.2</i>	<i>18.6</i>	19.8	19.0	19.0	--	--	--	--	8.4	11.2	10.7	--	--	12.6	15.6	
9	--	15.2	16.3	19.0	18.9	19.0	--	--	--	--	7.6	11.2	10.7	--	11.8	12.0	14.8	
10	14.8	15.0	<u>16.0</u>	17.8	18.8	18.9	17.4	10.6	7.0	5.0	7.2	8.0	9.4	11.2	--	11.8	14.4	
11	14.0	14.6	14.4	26.2	16.7	18.2	17.4	--	7.0	5.0	--	7.6	--	--	11.3	11.8	14.2	
12	--	--	--	15.0	15.4	15.5	--	--	--	--	--	7.2	--	--	--	11.4	13.8	
13	13.2	13.7	13.7	13.8	14.3	14.4	<u>17.4</u>	--	7.0	--	7.0	--	9.0	--	10.9	10.8	13.2	
14	--	--	--	13.3	13.5	13.8	13.8	--	--	--	--	--	--	--	--	11.0	12.8	
15	12.6	12.8	12.9	13.2	13.4	13.4	13.4	10.4	7.0	5.0	6.7	7.1	8.8	10.8	10.8	11.0	12.4	

\* Less than 1.0°C per meter

\*\* 15 meter depth station

Numerals in italics = Limits of thermocline

Underscore = Drop in temperature between adjacent meters

summer. However, records for 1949 (Table 2) indicate that the thermoclines became thinner and their upper limits deeper between late summer and the end of the stratification period in autumn. A phenomenon often encountered in this study was a sudden drop in temperature between two adjacent horizontal meter levels. In some instances this condition was found above the thermocline (Lake Atalanta in July and August), below the thermocline (Lake Fort Smith on August 9, 1949), or in place of a thermocline (Lake Fort Smith on November 4, 1949 and in Lake Atalanta on April 24, 1950). Secondary thermoclines (at least one meter in thickness) were present in Lake Fayetteville on July 26, 1949, and in Lake Fort Smith on August 9, 1949.

#### CIRCULATION PERIOD

Table 2 shows that, with a few exceptions, the lakes were unstratified from November into April. In two instances, thermal stratification occurred during the winter in the two lakes with the greatest wind protection; Lake Atalanta stratified on March 2, 1950, and Lake Hindsville on February 23, 1950. In general, the vertical temperatures during this time were either homothermal or had such a slight gradient that a small amount of wind was able to initiate circulation. Because it is possible for the lake to overturn at any time from November into April it is here considered as the circulation period. Chemical records taken from November into April show that dissolved oxygen, carbon dioxide, and pH readings were nearly uniform from surface to bottom on each sampling date. This would seem to indicate that the temporary thermal stratifications that appear during this time are not of sufficient duration to allow a chemical differentiation between levels.

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SOME CHEMICAL CHANGES RESULTING FROM INDUSTRIAL WASTE DISPOSAL  
IN THE OUACHITA RIVER

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During the summer of 1942 the Arkansas Game and Fish Commission equipped a field party to conduct a limnological survey of the Ouachita River, Arkansas, from Camden to Lock Eight. This river has two main tributaries entering it as it flows between these two points (Figure 1). The first, the upstream tributary, is West Two Bayou which contained paper-mill wastes from the Camden Mill of the International Paper Company, and also sewage from the City of Camden. During the summer in which this investigation was carried on only "wash-water" from the paper mill was introduced into West Two Bayou. At the time of this study the paper-mill and sewage pollution had been entirely dissipated by the time the river flow reached Spoon Camp, nine miles below West Two Bayou and nine miles above Miller's Bluff. The second, the downstream tributary, is Smackover Creek which contained chlorides and oil from the Smackover oil fields. The purpose of this paper is to reveal some chemical changes in the Ouachita River brought about by the introduction of chlorides from Smackover Creek at a time of the year when river flow is at its minimum.

ACKNOWLEDGEMENTS

The author is indebted to Joe Hogan, Superintendent of Fisheries, Arkansas Game and Fish Commission, for cooperation and assistance in all phases of this investigation; to John Dawson, Stephens, Arkansas, for courtesies extended while this work was in progress.

MATERIALS AND METHODS

The water samples for chemical analyses were collected with a modified Kemmerer sampler. Chemical determinations, with the exceptions of chloride and alkalinity, were completed in the field. Chemical determinations of dissolved oxygen, free carbon dioxide, alkalinity and chloride were made in accordance with methods described in the Standard Methods of Water Analysis (1936). Hydrogen-ion concentration determination were made with a Hellige disc colorimeter.

SAMPLING STATIONS

For the purpose of determining chemical changes in the Ouachita River brought about by the introduction of chloride-polluted water from Smackover Creek, ten regular stations were chosen from Miller's Bluff to Lock Eight. These stations were all far enough downstream from Camden to be free of paper-mill and sewage pollution. Station No. 1, at Miller's Bluff, was approximately six miles above Smackover Creek. This station was established because it was above any traces of pollution from Smackover Creek. For approximate distances between stations, refer to Figure 1. Station No. 2, Roark's Ferry, was four miles above Smackover Creek. This station along with Station No. 1 represents the natural conditions of the river. Station No. 3, one-fourth mile above Smackover Creek, was selected because preliminary sampling showed that pollution extended to this distance upstream. Station No. 4, established one-fourth mile within Smackover Creek, typifies the chloride conditions in the polluted tributary. Since no other sources of pollution were found between Smackover Creek and Lock Eight, the other stations were spaced at significant intervals between these two points.

RESULTS

Table 1 is a summary of vertical chemical conditions in the Ouachita River from Miller's Bluff to Lock Eight during August, 1942. Stations No. 1 and No. 2 represent unpolluted conditions in the Ouachita River which were: a maximum chloride reading of 30 ppm., dissolved oxygen present from surface to bottom, and near uniformity in both pH and free carbon dioxide between surface and bottom levels. As the chloride-polluted water from Smackover Creek entered the Ouachita River it flowed along the bottom of the stream bed downstream and, to a limited extent, toward upstream (Table 1). At all stations showing pollution (3 through 10), the heavy salt concentrations extended from the fourth meter to the bottom.

At Stations No. 3 through No. 7 the greatest chloride concentrations were found in the water on the bottom, while in Stations No. 8 and No. 10 there was a tendency for the salt to become somewhat equally distributed between the lowest two or three meters. Increased chloride concentrations were responsible for other chemical changes such as: a decrease in dissolved oxygen, an increase in free carbon dioxide, and an increase in hydrogen ions. At all stations below Smackover Creek the water next to the bottom was oxygen free while the water in the meter above that was either oxygen free or nearly so. Methyl Orange readings (due entirely to bicarbonate) are presented in Table 1. Water surface temperatures during the month of August varied from 30.0° C to 34.0° C.

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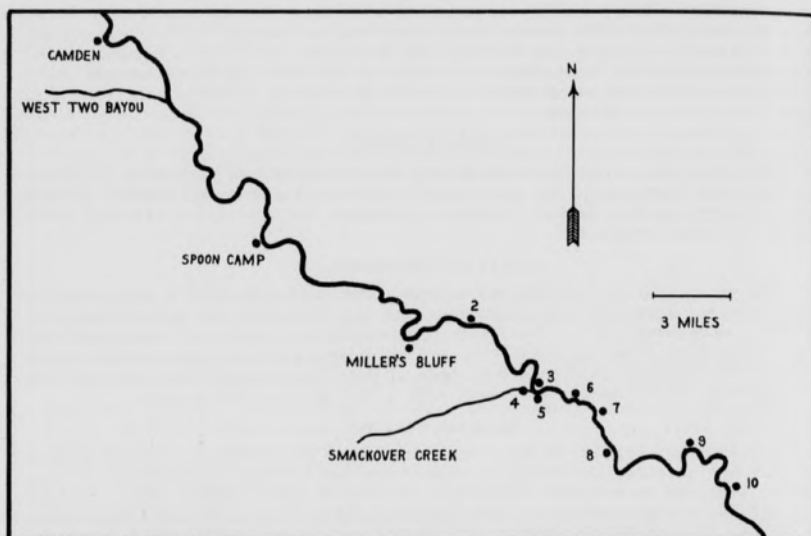


Figure 1. The Ouachita River from Camden to Lock Eight with location points and sampling stations.

Explanation of Figure 1. Location points and sampling stations along the Ouachita River with approximate distances above and below Smackover Creek.

Stations	Location Points		Mileage from Smackover Creek
	Camden	UPSTREAM	27.00
	West Two Bayou		24.00
	Spoon Camp		15.00
1	Miller's Bluff		6.00
2	Roark's Ferry		4.00
3	1/4 mile above Smackover Creek		0.25
4	1/4 mile within Smackover Creek (Mouth of Creek)		0.00
		DOWNSTREAM	
5	1/4 mile below Smackover Creek		0.25
6	2 miles below Smackover Creek		2.00
7	3 miles below Smackover Creek		3.00
8	Calion		5.00
9	Gas Line crossing		9.00
10	Lock Eight		12.00

Table 1. Chemical conditions in the Ouachita River from Miller's Bluff to Lock Eight during August 1942.

Station	Depth in Meters	Chloride ppm.	Oxygen ppm.	Free CO <sub>2</sub> ppm.	M. O. Alkalinity ppm.	pH
1 *	0.0	24.0	3.7	6.0	43.0	6.5
	9.0	30.0	3.7	8.0	41.0	6.5
2 *	0.0	24.0	4.0	3.0	46.0	6.5
	6.0	30.0	2.7	4.5	22.0	6.6
3 *	0.0	120.0	4.8	3.0	39.0	6.6
	1.0	120.0	4.8	- -	- -	- -
	2.0	120.0	3.8	5.0	38.0	- -
	3.0	120.0	3.7	- -	- -	- -
	4.0	4,200.0	2.6	9.0	39.0	6.5
	5.0	8,400.0	2.0	- -	- -	- -
	6.0	10,400.0	0.9	30.0	44.0	6.3
4	0.0	3,500.0	2.4	6.0	- -	6.5
	4.0	10,500.0	0.0	18.0	- -	6.3
5 **	0.0	66.0	4.4	4.3	40.0	6.6
	1.0	58.0	3.7	4.0	40.0	- -
	2.0	60.0	3.3	- -	40.0	- -
	3.0	70.0	3.5	- -	40.0	- -
	4.0	2,660.0	2.9	10.0	34.0	6.5
	5.0	7,100.0	0.9	- -	34.0	- -
	6.0	9,900.0	0.0	- -	36.0	- -
6 **	0.0	11,900.0	0.0	31.0	52.0	6.4
	0.0	86.0	- -	3.0	42.0	6.5
	2.0	94.0	3.8	- -	40.0	- -
	3.0	100.0	3.7	6.0	38.0	6.4
	4.0	6,780.0	2.9	- -	36.0	- -
	5.0	9,000.0	0.9	- -	32.0	- -
	6.0	9,600.0	0.0	- -	36.0	- -
7 **	0.0	10,200.0	0.0	25.0	42.0	6.3
	0.0	84.0	4.0	4.5	46.0	6.5
	1.0	202.0	4.1	- -	38.0	- -
	2.0	88.0	4.0	- -	36.0	- -
	3.0	92.0	3.7	5.0	42.0	6.4
	4.0	2,700.0	2.1	- -	34.0	- -
	5.0	7,900.0	0.3	- -	36.0	- -
8 **	0.0	10,400.0	0.0	25.0	50.0	6.3
	0.0	98.0	4.4	4.0	46.0	6.6
	1.0	140.0	4.1	- -	42.0	- -
	2.0	132.0	4.0	- -	34.0	- -
	3.0	134.0	3.7	4.0	34.0	6.5
	4.0	2,740.0	2.3	- -	42.0	- -
	5.0	9,500.0	0.0	- -	42.0	- -
9 **	0.0	9,300.0	0.0	25.0	58.0	6.4
	0.0	180.0	5.1	3.0	36.0	6.6
	1.0	260.0	4.5	- -	36.0	- -
	2.0	360.0	4.2	3.0	44.0	- -
	3.0	320.0	4.2	- -	40.0	6.4
	4.0	2,740.0	2.0	9.0	40.0	- -
	5.0	6,100.0	0.2	- -	42.0	- -
6.0	6,700.0	0.0	27.0	48.0	6.3	

Table 1, continued

Station	Depth in Meters	Chloride ppm.	Oxygen ppm.	Free CO <sub>2</sub> ppm.	M. O. Alkalinity ppm.	pH
10 **	0.0	340.0	4.8	3.0	40.0	6.6
	1.0	860.0	4.8	- -	48.0	- -
	2.0	860.0	4.8	- -	42.0	- -
	3.0	900.0	4.7	3.5	48.0	6.5
	4.0	1,100.0	2.9	- -	40.0	- -
	5.0	6,700.0	0.4	13.0	44.0	- -
	6.0	7,500.0	0.0	- -	50.0	- -
	7.0	7,600.0	0.0	25.0	56.0	6.4

\* Upstream from Smackover Creek

\*\* Downstream from Smackover Creek

## A STUDY OF THE COTTON RAT IN NORTHWESTERN ARKANSAS

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The cotton rat, *Sigmodon hispidus*, is one of the most common rodents in southern United States. In most southern states it is an important crop pest, causing severe damage to truck gardens and to such crops as cotton, sugar cane, and sweet potatoes. Destruction of quail eggs and eggs of other ground-nesting birds by cotton rats may seriously affect game-bird populations (Stoddard, 1931; Komarek, 1937). This mammal is also of major epidemiological importance in that it is a potential reservoir of such diseases as typhus and plague (Meyer and Meyer, 1944). Although the cotton rat has been studied by a number of investigators, very few of the studies are of a quantitative nature, and the only ones reported which involve any large number of specimens are those of Meyer and Meyer (1944), Odum (1947), Erickson (1949), and Stickel and Stickel (1949).

Because of the cotton rats' importance in connection with public health, agriculture, and wildlife it was felt that any information concerning this rodent in Arkansas would be of value, especially as no previous study, aside from distributional records, of this species has been made in Arkansas.

The present study was made on 180 northern cotton rats, *Sigmodon hispidus hispidus* Say and Ord, taken in the vicinity of Fayetteville, Washington County, Arkansas, from October, 1950 through June, 1951. Primary consideration was given to reproduction, seasonal weight changes among adult rats, and to criteria for separating the population sample into age classes.

### THE STUDY AREA

The study area consisted of eight separate trapping sites, which varied in size from about two to four acres, located in and around Fayetteville, Washington County, Arkansas. The chief vegetational cover in these areas consisted predominantly of broom sedge (*Andropogon virginicus* and *Andropogon scoparius*). Broom sedge occurred mainly on burned-over areas and old fields, and appeared to be one of the first seral stages following burning or denudation of the land. The separate trapping areas differed to some extent in the amount of dead, matted vegetation, proximity to water and wooded areas, and in the number of associated plant species. One of the trapping sites, located about one mile north of Fayetteville, had only scattered clumps of broom sedge, and ragweed (*Ambrosia* sp.) comprised much of the plant cover. Swamp sedge, (*Carex* sp.) also was more abundant than broom sedge in this area.

### METHODS

Victor mouse traps and rat traps and small (2' x 2.5' x 6.5') Sherman live traps were used in the study. Line trapping was employed, with individual traps set about four feet apart and placed so that they faced out into runways. The number of traps set along a given line was determined by the number of suitable trapping sites. In general, a sheltered trap site produced the best catches, and maximum catches were obtained by placing traps along avenues of travel, such as brush piles, logs, stream banks, and matted grass. Except during December and January, traps were attended at least once a day, usually early in the morning. Each trapping site was intensively trapped until it was felt that the population was exhausted, as evidenced by absence of captures over periods of several days' trapping. Traps were moved about in various parts of each area in order to gain some idea of habitat preference.

Traps were baited with oatmeal, peanut butter, prunes, and raisens. All of these proved to be effective baits, but the degree of effectiveness showed considerable seasonal and daily variation. No specimens were captured with rain-soaked oatmeal. This agrees with the results of Anderson (1948) in Canada. Peanut butter was most effective in early spring and late autumn. Cotton rats may have been discouraged from eating this bait during the warmer months when ants



swarmed on it. Rain often washed the peanut butter from the trap pan, reducing the efficiency of the snap traps. Prunes and raisins were most effective during colder weather as they were little affected by climatic change. Erickson (1949), who used oatmeal and chickmash as baits, obtained his largest catches in times of least rainfall. He found that trapping success was little affected by temperature or by relative humidity.

Each specimen was weighed shortly after capture to the nearest one-tenth of a gram. Standard measurements were made to the nearest one-tenth millimeter with a vernier caliper.

#### RESULTS AND DISCUSSION

**COTTON-RAT, SMALL-MAMMAL INTERRELATIONSHIPS:** During the course of this study five house mice (*Mus musculus*) seven harvest mice (*Reithrodontomys fulvescens aurantius*), five white-footed mice (*Peromyscus leucopus*), one little short-tailed shrew (*Cryptotis parva*), and one short-tailed shrew (*Blarina brevicauda carolinensis*) were captured in cotton-rat runways.

Interrelationships can only be surmised from so few captures. All the white-footed mice were taken on high, comparatively dry ground where few cotton rats were captured. The house mice were taken in close proximity to buildings where cotton rats were seldom taken. Harvest mice, however, were taken in several of the trapping sites, usually where the most cotton rats were taken. Both harvest mice and cotton rats show a marked preference for broom-sedge habitat, although no indication has been obtained that they are active competitors. Other species taken do not appear to share the identical habitat of the cotton rat, but their presence is probably indicative of some overlap in habitat requirements.

Few literature references are made to interrelationships of the cotton rat with other small mammals. Coleman (1929) frequently captured harvest mice in cotton rat runways, while Stickel and Stickel (1949) captured twenty-one Taylor Baiomys (*Baiomys taylori*) along with eighty-three cotton rats during a nine-day trapping period.

**COTTON-RAT HABITAT:** It is generally agreed (Hamilton, 1943; Stickel and Stickel, 1949; Erickson, 1949; and others) that the preferred habitat of the cotton-rat is in heavily matted grasses with a preference toward a matting of broom sedge. Svihla (1929) found them common in the coastal marshes and cane fields of Louisiana, and Cahalane (1939) found them most numerous under conditions of abundant moisture along irrigation ditches and in cattail marshes of the Chiricahua mountain region of Arizona.

In the region around Fayetteville, cotton rats seemed to prefer matted broom sedge bordering rather moist areas rather than swampy ground. During one month in which records were kept of captures in various parts of a two-and-one-half-acre field of broom sedge within the Fayetteville city limits, the most captures were made in the zone between swampy and dry ground (Table I). Captures decreased progressively with increased distances from this zone. Portions of the trapping area which lacked a grass matting yielded only an occasional rat, whereas portions with a heavy matting yielded the greatest percentage of the total catch.

Cotton-rat runways in the study area were very distinct on open ground, and in many places they were so well worn that no vegetation grew on them. The majority of the runways observed were distinct for only ten to twenty feet and then faded out into many side passages. However, one runway was observed which could be clearly followed for nearly one hundred feet. Many cotton rats of various sizes were seen running along well-marked runways in the study area, and on two separate occasions these rodents were observed while in the process of constructing new runways. In runways which were in use, the characteristic spindle-shaped scat of the cotton rat could generally be found.

Hamilton (1943) states that cotton-rat runways are well-defined trails even where the ground surface is open, but Jameson (1947) and Stickel and Stickel (1949) state that the runways which they studied were ill-defined even in matted regions.

Table 1. Numbers and percentages of the total catch of 26 cotton rats in a two-and-one-half-acre field of broom sedge during April, 1951.

Moisture Conditions	Total Catch			
	Matted Broomsedge		Non-matted Broomsedge	
	Number	Per cent	Number	Per cent
Swampy	2	7.7	0	0.0
Moist	20	76.9	2	7.7
Dry	1	3.8	1	3.8

**ACTIVITY:** During the early winter months, cotton rats were observed traversing runways at all times of the day in various parts of the study area. When traps were checked several times a day during the spring months, however, it was found that very few specimens were captured from the post-dawn to pre-dusk hours, indicating that this species may be least active during midday. It is possible that the high degree of activity during the winter was due to scarcity of food, or to low temperature combined with food shortage. It is felt that the quiescent period during midday is more typical of the warmer months.

**PREDATION:** A certain amount of incidental information concerning predation upon cotton rats resulted from the study, although the effect of predation upon trapping success or upon cotton-rat populations could not be measured.

In one of the trapping areas, domestic cats seemed to be the chief predators. They were observed working the fields at all times of the day, and on two occasions were observed while capturing cotton rats. Examination of their scat revealed that a considerable portion of it was composed of fur and teeth, which upon comparison with reference material, proved to be from cotton rats.

On May 18, 1951, a five-foot coachwhip snake (*Coluber flagellum*) was captured and killed in a trapping area west of Fayetteville. Its stomach contained a freshly-killed, pregnant cotton rat.

From three to ten red-tailed hawks (*Buteo borealis borealis*) were seen perched in trees daily for over fifty days in a trapping site north of Fayetteville. One specimen was shot and wounded in a tree on the trapping site, and shortly after being captured regurgitated a freshly-killed cotton rat. Three pellets, probably from these hawks, containing cotton rat remains were found at the base of a tree in the same area.

About ten per cent of all cotton rats caught in snap traps were either partially eaten or removed from the traps. It seems likely that at least some of these specimens were cannibalized, while the remainder probably were eaten by scavengers or chance predators. Undoubtedly certain animals will readily eat trapped animals which ordinarily they are unable to capture. For example, both a crow and a four-pound snapping turtle were captured in steel traps baited with cotton rats during this study. Animals such as these should be considered as occasional scavengers rather than true predators.

**AGE AND WEIGHT:** Separation of Age Classes -- Determination of the age composition of a sample of a cotton-rat population is subject to considerable inaccuracy when based upon weights, measurements, and reproductive condition of specimens gathered in the field, when these data are not compared with similar measurements on animals of known age. Age criteria for cotton rats used by other workers (Erickson, 1949; Stickel and Stickel, 1949) have been based chiefly upon a rough quantitative and/or qualitative estimation of size and of breeding condition.

Size is not a good index of sexual maturity in the cotton rat, inasmuch as cotton rats are capable of breeding at about 40 days of age (Meyer and Meyer, 1944; Asdell, 1946), at which time they are still undergoing rapid growth and may be considerably less than half the size of a fully-grown rat. There is also evidence that puberty is reached earlier in spring than in autumn, so that breeding may occur at 30 days of age or possibly at a younger age. Thus, animals

classed as juveniles and subadults on the basis of body measurements or weight may be called adults, if sexual maturity is considered the criterion for the adult condition. On the other hand, age-criteria based solely upon reproductive condition may be unreliable because of seasonal changes in reproductive condition.

Young cotton rats are quite precocious and leave the nest to forage for themselves at about ten days of age (Svihla, 1929). Growth is rapid (*ibid.*), and the rate is fairly constant, not showing a marked decrease until after 100 days of age (Meyer and Meyer, 1944). Meyer and Meyer (1944) state that a large part of the weight gain after 100 days of age is in the form of fat.

The data of Meyer and Meyer (1944) has been used in determining the age composition of the cotton-rat population sample considered in this study. They raised cotton rats from birth in the laboratory and weighed groups of males and females at 10, 20, 30, 40, 50, 100, 150, 200, and 250 days of age. The data on field-caught rats in the present study has been compared with these known weights to obtain the approximate age composition of the sample. Cognizance has been taken of the fact that laboratory-reared rats became fatter, and hence heavier, than wild rats. However, most of the heavy fat deposits observed in wild cotton rats have been in obviously larger and older animals, and should not appreciably affect the age groupings in view of the weight ranges chosen to represent different age groups.

The population sample was divided into three age groups on the basis of weight: Subadults, young adults, and old adults. Male and female animals weighing from 12 to 46 grams were classed as subadults ranging in age from 10 to 29 days. All male animals weighing from 47 to 138 grams were classed as adults ranging in age from 30 to 50 days, while all females weighing from 47 to 111 grams were considered as adults ranging in age from 30 to 50 days. Males weighing from 139 to 258 grams were classed as old adult males ranging in age from 51 to 250 or more days. Old adult females were considered to be specimens weighing from 112 to 230 grams and ranging in age from 51 to 250 or more days. The weight ranges used for old males and old females varied somewhat in view of the findings of Meyer and Meyer (1944) that males tend to accumulate weight faster than do females after 50 days of age.

A fourth weight range of 3.5 to 11 grams was selected to represent juvenile or young animals ranging in age from 1 to 9 days. None of the specimens collected fell into this category, so it is presumed that animals of this age either remain close to the nest or do not readily enter traps in search of food.

Table II, Age composition of a cotton-rat population in the vicinity of Fayetteville, Arkansas, based upon body weights<sup>1</sup> with correlated body measurements for each age group.

Age Class	Sex	No. of rats	Weight Range (grams)	Average Weight <sup>2</sup> (grams)	Average body measurements <sup>3</sup> (millimeters)			
					Total Length	Tail Length	Hind Foot	Ear
Sub-adult	M	23	12-46	28.7 (13.2-46)	160.3 (125-215)	68.9 (53-110)	23.8 (19-28)	14.0 (10-17)
Sub-adult	F	12	12-46	38.2 (18.7-44.9)	187.7 (137-221)	82.9 (61-105)	26.4 (22-29.5)	16.1 (13-18)
Young adult	M	68	47-138	80.4 (47.8-137)	214.3 (150.7-270)	86.0 (60-110)	29.5 (25.1-33)	17.4 (14-20)
Young adult	F	49	47-111	69.9 (50-108.1)	207.2 (150-240)	80.6 (50-100)	28.6 (25.9-31)	17.0 (13.9-20)
Old adult	M	8	139-258	160.3 (140-210)	267.3 (256-300)	100.8 (93-107)	31.3 (30-33)	19.5 (18-20)
Old adult	F	20	112-230	132.5 (114.6-191.5)	249.2 (217-293)	98.7 (65-119)	30.2 (26-34)	18.8 (15-20)

1. Cf. Meyer and Meyer (1944)

2. Range in parentheses

3. Range in parentheses

As shown in Table II, males tended to average somewhat heavier than females, except among the subadult class where it appears that the initial growth rate of females probably is more rapid than that of males. The average body weights in the different age classes tended to be somewhat lower than those of laboratory-reared rats in the same weight range, which is to be expected on the basis of comparative growth rates of wild and captive stock (Svihla, 1929; Meyer and Meyer, 1944). Standard body measurements tend to show a considerable amount of overlap between different age groups based on weight, and hence they must be used cautiously as a criterion of age.

The monthly catches of specimens in each age class are summarized in Table III. The monthly percentages of each age class in the population are shown in Figure 1. Changes in percentages of subadults, young adults, and old adults reflect the changing age composition of the population as a whole as reproduction ceases during part of the winter and natural mortality of old adults occurs. With resumption of breeding in the spring months, there was an apparent trend toward a decrease in the percentage of young adults in the population, and in the late spring and early summer months, there was an increase in the percentage of old adults. This is largely accounted for by the maturation of the young adult class into old adults, and a rapid increase in the number of subadults. Komarek (1937) noted that there was a regular yearly decrease in cotton-rat numbers during spring, at which time they evidently reached a population low point.

Table III. Summary of monthly catches of cotton rats of each age class taken in the vicinity of Fayetteville, Arkansas, from October, 1950, through June, 1951.

Month	Number Captured	Per cent of monthly catch	Number Captured	Per cent of monthly catch	Number Captured	Per cent of monthly catch
October	0	0.0	6	85.7	1	14.3
November	11	33.3	21	63.6	1	3.1
December	0	0.0	22	91.7	2	8.3
January	0	0.0	14	93.3	1	6.7
February	7	26.9	19	73.1	0	0.0
March	3	33.3	6	66.7	0	0.0
April	6	22.2	19	70.5	2	7.3
May	5	19.2	10	38.5	11	42.3
June	3	23.1	2	15.4	8	61.5
Total	35		119		26	
Per cent of Total Catch		19.4		66.1		14.5

**BODY WEIGHT AND FAT ACCUMULATION:** An arbitrary criterion, based upon the gross amount of visible fat in each specimen autopsied, was used to indicate the relative amount of fat deposition in males and females during different months (Table IV).

The time sequence of fat deposition and of depletion of fatty tissue was almost identical in males and females. During the months of November, December, and January, males acquired fat deposits in the posterior body regions about two weeks before females did but these deposits were lost at approximately the same date in both sexes.

Pectoral fat was acquired last and disappeared first in both sexes. Omental and gonadal fat appeared simultaneously with inguinal and anal fat, but disappeared last. During November, December, and January males showed greater fat deposition than females in the inguinal, omental, gonadal, and anal regions.

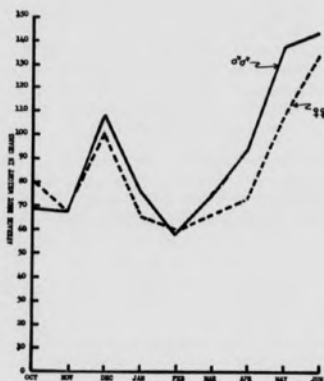
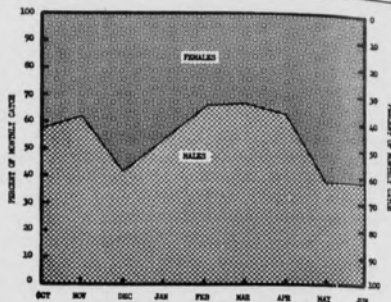
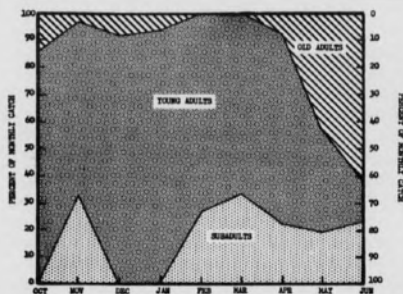


Fig. 1. (Above left) Per cent of monthly catches of cotton rats of each age class taken from October, 1950, through June, 1951 in the vicinity of Fayetteville, Arkansas.

Fig. 2. (Left) Average monthly body weights of 145 adult cotton rats taken in the vicinity of Fayetteville, Arkansas, from October, 1950, through June, 1951.

Fig. 3. (Above) Monthly percentages of male and female cotton rats captured in the vicinity of Fayetteville, Arkansas, from October, 1950, through June, 1951.

Table IV. Relative amount of fat accumulation in six regions of the body of male and of female cotton rats taken in the vicinity of Fayetteville, Arkansas, from October, 1950, through June, 1951.

Month	Sex	Number of Rats	Body Region					
			Pectoral	Inguinal	Omental	Renal	Gonadal	Anal
October	M	4	0	0	0	0	0	0
	F	3	0	0	0	0	0	0
November	M	21	0	1	1	0	1	1
	F	12	0	0	0	0	0	1
December	M	10	1	1	2.5	2.5	2.5	2.5
	F	14	1	1	2.0	2.0	2.0	2.0
January	M	8	3.0	3.0	3.0	3.0	3.0	3.0
	F	7	1.5	1.5	1.5	1.5	1.5	1.5
February	M	17	0.5	0.5	0.5	0.5	0.5	0.5
	F	9	0.5	0.5	0.5	0.5	0.5	0.5
March	M	6	0	0.5	0.5	0	0.5	0.5
	F	3	0	0.5	0.5	0	0.5	0.5
April	M	17	0	0	0.5	0	0.5	0
	F	10	0	0	0.5	0	0.5	0
May	M	16	0	0	0	0	0	0
	F	5	0	0	0	0	0	0
June	M	5	0	0	0	0	0	0
	F	8	0	0	0	0	0	0

Key 0 - absent; 1 - slight; 2 - medium; 3 - heavy

These observations indicate that heaviest fat deposition took place during the winter months and least fat deposition in late autumn and early spring months. Visible fat deposits were absent during late spring and early autumn. It is presumed that this condition is maintained throughout the summer months.

Monthly weights of male and female cotton rats are presented in Table V. Weight curves for male and female cotton rats (Figure 2) show a definite trend toward increasing weight in both sexes during the spring and summer months. As shown in Table IV, fat deposition was rapid, occurring mainly in December and January, with evident withdrawal of depot fat during February and March as body weights of both sexes declined (Table V, Figure 2) probably as the result of severe weather and food shortages. Bailey (1931) noted that cotton rats in the wild do not accumulate any noticeable amount of fat.

#### REPRODUCTION

**SEX RATIO:** Cotton-rat populations probably have a nearly-equal sex ratio. Stickel and Stickel (1949) and Erickson (1949) report sex ratios of 42:40 (105:100 and 84:68 (124:100), respectively. Both studies point out that males range further than females. The greater tendency of males to wander results in more frequent capture, thereby distorting the true sex ratio.

In this study, a sex ratio of 98:82 (120:100) was found for the population sample. A sex ratio of 9:8 (110:100) was found in three litters of cotton rats, which compares closely with the sex ratio of the population sample. Monthly sex ratios are summarized in Table VI. The increase in percentage of males during February, March and April (Figure 3) appears to coincide with the onset of the breeding season. At this time males apparently range further, probably in search of females, and evidently are more active, resulting in greater frequency of captures. Females, on the other hand, probably become more retiring while rearing litters, and hence are less frequently captured during this period. The increase in percentage of females during May and June may be indicative of a population trend which was not, however, followed through trapping during succeeding months. The decline in number of males caught and the increase in number of females caught (Table VI, Figure 3) may indicate some sort of compensatory population adjustment, whereby a low population density may be compensated for by an increase in number of females, thus restoring the reproductive potential of the species (Elder, 1951). Elder (personal communication) mentions an apparent decline of cotton-rat populations in Missouri during 1951, based on a reduction of fifty percent in frequency of occurrence in stomachs of predators. A similar decline may have occurred in Arkansas. Other workers also have noted a tendency toward unbalanced sex ratios with changes in population levels (cf. Linduska, 1950.)

**LITTER SIZE:** During the present investigation, 23 females were found containing embryos, placental scars, or both. Seven females taken during November and December contained from 5 to 22 placental scars. Visible embryos did not appear until April, when one female contained five visible embryos which were approximately 7 millimeters long. Assuming no intra-uterine mortality once the embryos have become visible in the horns (Emlen and Davis, 1948), the litter size in 16 pregnant females varied from 4 to 10 with an average of 6.6. The average litter size for May was 6.0, and for June it was 7.6. These litter sizes compare favorably with those found by other workers (cf. Asdell, 1946).

**BREEDING POTENTIAL:** Assuming that the period of visible pregnancy in the 27-day gestation period of the cotton rat (Meyer and Meyer, 1944) is directly proportional to that of the Norway rat (which is 18 days of the 21-day gestation period), then the period of visible pregnancy for the cotton rat is 23 days.

Using this figure, frequency of pregnancy can be calculated by the following formula (Emlen and Davis, 1948).

$F \approx I \times t/23$ , in which

F = Frequency of pregnancy

I = Incidence (percentage visibly pregnant)

t = Length of time during which specimens were collected

Of the nine-month period, 219 days were spent trapping. During the study, 41 adult females were trapped, of which 16 (39.0 per cent) were visibly pregnant. Applying the equation for determination of pregnancy frequency,

$$F = 0.39 \times 219/23$$

we obtain,

$$F = 3.71$$

According to the above calculation, the average adult female brought 3.71 litters successfully to term in the 219-day study period. This is equivalent to a rate of one litter every 59 days, or six litters per year. Using the same formula, Emlen and Davis (1948) obtained a pregnancy frequency of 3.44, or one litter every 65 days for wild brown rats. Svihla (1931) found that one Texas rice rat produced six litters in a year, or one litter every 40.55 days. The breeding potentials of these two prolific rodents thus compare favorably with that found for the cotton rat in this study, definitely indicating its high degree of productivity.

PROBABLE LENGTH OF THE BREEDING SEASON: The data are insufficient to determine the actual length of the breeding season. The latest record of placental scars was on December 12, 1950, while the earliest record of visible embryos was on April 19, 1951. The largest number of pregnant females were taken in May and June. Two separate breeding periods seem to be indicated by the bimodal distribution of the subadult population, and, to a lesser degree, the adult population (Figure 1). One major breeding period may have its onset in February or March and probably continues through July, while another shorter breeding period may begin in late September or October and continue through November.

Table V. Monthly weights of 145 adult male and female cotton rats taken in the vicinity of Fayetteville, Arkansas, from October, 1950, through June, 1951.

Sex	Month	Number Captured	Average Weight (grams)	Weight Range (grams)
Males	October	4	68.5	50.3 - 120.0
	November	10	67.8	49.2 - 100.0
	December	10	18.0	84.3 - 145.0
	January	8	76.9	58.3 - 96.3
	February	14	58.6	48.0 - 87.1
	March	4	75.0	60.0 - 91.0
	April	14	93.9	62.6 - 152.0
	May	9	137.6	77.2 - 210.0
	June	3	143.7	126.0 - 168.0
Females	October	3	80.5	56.0 - 127.5
	November	12	67.9	50.0 - 128.5
	December	14	100.2	53.6 - 191.5
	January	7	65.5	52.1 - 114.6
	February	5	59.5	55.0 - 65.1
	March	2	66.4	52.3 - 80.5
	April	7	73.6	60.0 - 80.0
	May	13	108.7	60.0 - 142.0
	June	6	133.2	118.2 - 150.0

Table VI. Summary of monthly catches of male and female cotton rats of all age classes taken in the vicinity of Fayetteville, Arkansas, from October, 1950, through June, 1951.

Month	Number of Males	Per cent of Monthly Catch	Number of Females	Per cent of Monthly Catch	Sex Ratio
October	4	57.9	3	42.1	133:100
November	21	63.6	12	36.4	175:100
December	10	41.7	14	58.3	71:100
January	8	53.3	7	46.7	114:100
February	17	65.4	9	34.6	189:100
March	6	66.6	3	33.3	200:100
April	17	62.6	10	37.4	170:100
May	10	38.5	16	61.5	63:100
June	5	38.5	8	61.5	63:100
Total	98		82		120:100
Per cent of Total catch		54.4		45.6	

#### SUMMARY

A study was made on a cotton-rat population in and around Fayetteville, Washington County, Arkansas, from October, 1950 through June, 1951. Emphasis in the study was placed on body measurements and reproductive condition, with the objective of determining age composition and reproductive status of the population. Some consideration was given also to habitat, activity, predation, and cotton-rat, small-mammal interrelationships.

The population was divided into three groups on the basis of weight: Subadults, young adults and old adults. Young adults (47-138 grams) comprised over 66 per cent of the total population, while subadults (12-46 grams) and old adults (112-258 grams) made up over 19 and 14 per cent of the total population, respectively. No individuals which could be classed as juveniles were trapped during the study. Monthly catches showed shifts in the proportion of different age groups in the population, which could be accounted for by changes in reproductive status of the population, coupled with natural mortality of older individuals and maturation of subadult and young-adult animals.

Heaviest fat deposition occurred during the winter months. No visible fat deposits were present during late spring and early autumn, although both sexes showed a definite trend toward increasing weight during this period. Fat deposition was rapid, and apparently occurred mainly in December and January, with evident withdrawal of depot fat during February and March. In general, male cotton rats averaged heavier in weight than females, except in the subadult class.

A sex ratio of 120:100 was found for the population sample. There was some evidence of shift in the sex ratio from February through June, possibly indicating a compensatory population adjustment whereby a decline in the total population may have been compensated for by an increased percentage of females.

Visible embryos were found in 16 females. The average litter size was found to be 6.6, assuming no intra-uterine mortality, with a range of 4-10. A reproductive rate of one litter every 59 days for an average adult female was calculated from the percentage of visibly pregnant females among the adult females in the population during the entire trapping period. The length of the breeding season could not be determined accurately from the data available.



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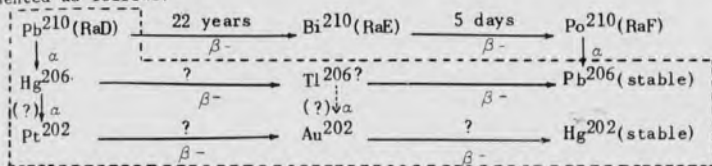
## THE POSSIBILITY OF WEAK ALPHA BRANCHING IN RADIUM D

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and R. W. FINK

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Up to now, naturally occurring radium D has not been known to emit alpha-particles. However, work in the chemistry department at the University of Arkansas has indicated that such a weak alpha branch may exist in the decay of radium D -- in fact, preliminary study supports such a hypothesis. Nuclear shell theory also supports an argument for the enhanced stability of the alpha-decay daughter,  $\text{Hg}^{206}$ , leading to a measurable lifetime. The general decay scheme may be represented as follows:



The enclosed portion represents the region under study, and the question marks indicate unknown entities.

The solution to this problem lies in the preparation of sufficient amounts of  $\text{Hg}^{206}$ . The present method is to isolate mercury from the radium D present in aged radon needles. The activity husbanded in this way is quite small, and while it is sufficient for some experiments, it is too small for others. Larger amounts of  $\text{Hg}^{206}$  might be produced by second-order neutron capture in highly enriched  $\text{Hg}^{204}$ , using the highest neutron flux facility available, such as the MTR reactor at Oak Ridge or at Arco, Idaho. If we should fail to detect this reaction, we should be able to set an upper limit for the product  $\sigma_2 \lambda_2$  where  $\sigma_2$  is the cross section for reaction  $\text{Hg}^{205}(n, \gamma)\text{Hg}^{206}$ , and  $\lambda_2$  is the decay constant of  $\text{Hg}^{206}$ .

One approach to the investigation of  $\text{Hg}^{206}$  will be to examine its possible beta-decay daughter, 4.3-minute  $\text{Tl}^{206}$ : Gross decay of a mercury fraction which was chemically separated from radium D by a sulfide separation, which does not provide an adequate decontamination factor from polonium or bismuth, exhibited a curve whose period of maximum growth occurred at 250 hours. This would rule out the possibility that  $\text{Hg}^{206}$  decays to 4.3-minute  $\text{Tl}^{206}$ , but leaves the possibility that it may decay to some unknown isomeric level in  $\text{Tl}^{206}$ , or that it may decay by alpha emission. The neutron absorption cross-section of  $\text{Tl}^{205}$  has been reported<sup>1</sup> as 0.77 barns by the pile-oscillator technique while the activation cross section of 4.3-minute  $\text{Tl}^{206}$  has been reported as only 0.10 barn. The difference is attributed to the existence of one or more long-lived isomeric levels in  $\text{Tl}^{206}$ , which is activated simultaneously. Shell structure predicts the existence of many low-lying high-spin states in odd-odd  $\text{Tl}^{206}$ , which has 81 protons and 125 neutrons, just one proton and one neutron short of a closed shell. The unknown isomeric level cannot be shortlived, for it either would feed the 4.3-minute state and contribute to its activation cross section, or it would independently beta-decay. The latter would hardly have escaped notice in the past. Moreover, it is doubtful that an ordinary lifetime (hours, days, or months) would have gone undetected. Thus, we predict that the isomeric level has a half-life either very long or similar to that of  $\text{Tl}^{204}$  (about 3 years).

Another possibility is that  $\text{Hg}^{206}$  may be beta-stable, and decays by alpha emission. In early studies a 70-hour daughter of  $\text{Hg}^{206}$  has shown up. Further work is planned to establish the identity of the 70-hour activity, which might be due to unknown  $\text{Pt}^{202}$  decaying to a possible short-lived  $\text{Au}^{202}$  daughter.

That  $\text{Tl}^{206}$  might undergo orbital electron capture to  $\text{Hg}^{206}$  is also within the realm of speculation. We plan to test this idea by studying the ratio of X-ray-decay/beta-decay of aged (2 to 5 years) and young samples of long-irradiated

<sup>1</sup> "Neutron Cross-Sections," U.S. Atomic Energy Commission Report AECU-2040.

elemental thallium. Should this ratio prove to be different between the young and the old samples, it would indicate that the beta-decay and orbital electron-capture arise from states of different lifetime, and perhaps from different nuclides. The next step would be to irradiate isotopically enriched thallium in an attempt to identify these states.

We have established a reliable procedure for chemically isolating and decontaminating the radium-D decay products involved to study their radiation characteristics. Our new technique, which supplants the unsatisfactory sulfide method mentioned earlier, is based on the following principles: (1) that  $\text{Pb}(\text{NO}_3)_2$  is insoluble in fuming nitric acid; (2) that bismuth and polonium do not extract into isoamyl acetate from a dilute nitric acid aqueous phase; and (3) that mercury can be stripped from the isoamyl acetate layer by 1M ammonium chloride aqueous solution. Thus, a carrier-free technique, easily adaptable for the isolation of any of these elements, is at hand for the separation, carrier-free, of radium-D, -E, and -F. The radiations emitted by  $\text{Hg}^{206}$  will first be investigated, using the following counting techniques: (1) gross alpha and beta decay in a windowless flow counter; (2) hard beta-decay through absorbers; and (3) gamma decay and energy by scintillation spectrometry.

ALGEBRAIC RELATIONS FOR PROPERTY-COMPOSITION  
CURVES OF BINARY MIXTURE

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Application of the Dimension Principle to an appropriate equation of state gives these relations by a purely formal method. Using the equation of van der Waals: (1)

$$(P + \frac{a}{\bar{V}^2})(V - b) = RT \quad (1)$$

one gets thus for  $\bar{V}$  of vapor (2) or liquid phase (3):

$$\text{Dim } [\bar{V}] = b \quad \bar{V} = \bar{v}_1 y^2 + ky(1-y) + \bar{v}_2(1-y)^2 \quad (2) \quad y: \text{ molefraction}$$

$$V = v_1 x^2 + Kx(1-x) + v_2(1-x)^2 \quad (3) \quad x: \text{ " "}$$

(at const. T)

of first component and  $\bar{v}_1, \bar{v}_2$  or  $v_1, v_2$  volumes of pure components. For a binary mixture the volume is a function of second degree in  $y$  or  $x$ . The constants  $k$  and  $K$  must be found with help of Thermodynamics or Statistics. For  $P$  one gets:

$$\text{Dim } [P] = \frac{a}{b^2} \text{ and thus: } P = \frac{a_1 x^2 + A_p x(1-x) + a_2(1-x)^2}{[b_1 x^2 + Bx(1-x) + b_2(1-x)^2]^2} \quad (4)$$

(at const. T)

$$\text{For } x=1 \therefore P = P_1 \therefore a_1 = b_1^2 P_1$$

$$\text{" } x=0 \therefore P = P_2 \therefore a_2 = b_2^2 P_2$$

where  $P_1$  and  $P_2$  are the vaporpressures and  $b_1$  and  $b_2$  the values for the components, calculated by the additivity rules of van Laar (Zustandsgleichung, 1931) from the  $b$  values of the elements.  $B$  is found from:

$$B = 2 b_{12} \text{ and } 2 \sqrt[3]{b_{12}} = \sqrt[3]{b_1} + \sqrt[3]{b_2} .$$

$A_p$  can be found from thermodynamics, as shown below. For  $T$  one has:

$$\text{Dim } [T] = \frac{a}{b} \text{ and thus: } T = \frac{\bar{a}_1 x^2 + A_t x(1-x) + \bar{a}_2(1-x)^2}{b_1 x^2 + Bx(1-x) + b_2(1-x)^2} \quad (5)$$

(at const. P)

$$\text{For } x=1 \therefore T = T_1 \therefore \bar{a}_1 = b_1 T_1 \left. \vphantom{\text{For } x=1} \right\}$$

$$\text{" } x=0 \therefore T = T_2 \therefore \bar{a}_2 = b_2 T_2 \left. \vphantom{\text{" } x=0} \right\}$$

where  $T_1$  and  $T_2$  are the boiling points for the components.

$A_p$  can be found - at low pressure and temperature - from the Gibbs-Duhem relation:

$$x p_2 p'_1 + (1-x) p_1 p'_2 = 0 \quad \text{where } p_2 = \text{Partial Pressure of components.}$$

Writing for these:

$$p_1 = \frac{a_1 x^2 + A_1 x(1-x)}{[b_1 x^2 + Bx(1-x) + b_2(1-x)^2]^2} \quad p_2 = \frac{a_2(1-x)^2 + A_2 x(1-x)}{[b_1 x^2 + Bx(1-x) + b_2(1-x)^2]^2}$$

where  $P = p_1 + p_2$  and  $A_p = A_1 + A_2$ .

and using the fact, that one has for many mixtures:

$$P_1 = P_2 \quad \text{for} \quad \bar{x} = \frac{P_2}{P_1 + P_2}, \quad \text{the Gibbs-Duhem}$$

relation gives:

$$\bar{x} p'_1 + (1-\bar{x}) p'_2 = 0 \quad \text{and}$$

$$a_1 \bar{x}^2 + A_1 \bar{x} (1-\bar{x}) = a_2 (1-\bar{x})^2 + A_2 \bar{x} (1-\bar{x})$$

so that:

$$\left. \begin{aligned} \bar{x}[1-2\bar{x} - m\bar{x}(1-\bar{x})] A_1 &= a_2(1-\bar{x})^2 - a_1\bar{x}^2(1-m\bar{x}) \\ (1-\bar{x})[1-2\bar{x} - m\bar{x}(1-\bar{x})] A_2 &= a_2(1-\bar{x})^2(1+m\bar{x}) - a_1\bar{x}^2 \end{aligned} \right\} \bar{x} = \frac{P_2}{P_1+P_2}$$

$$\text{where} \quad m[b_1\bar{x}^2 + B\bar{x}(1-\bar{x}) + b_2(1-\bar{x})^2] = 4b_1\bar{x} + 2B(1-2\bar{x}) - 4b_2(1-\bar{x}).$$

Thus  $A_p = A_1 + A_2$  is found for the P-x curve. From

$$P_1 = y^P \quad \text{one gets then:} \quad y = \frac{a_1 x^2 + A_1 x(1-x)}{a_1 x^2 + A_p x(1-x) + a_2 (1-x)^2}$$

and thus  $y = f(x)$  is found at const. T.

In order to find  $A_t$  for the T-x curve (P const.), one starts from the P-x curve, which is applied at:

$$2\tilde{T} = T_1 + T_2 \quad \text{and} \quad \tilde{P} = 1 \text{ atm.}$$

As  $A_p$  at this  $\tilde{T}$  and  $\tilde{P}$  can be calculated, one finds the value of  $\tilde{x}$  belonging to this T and introduction of this  $\tilde{x}$  into (5) gives then  $A_t$ .

These functions can then be applied to other thermodynamic relations. For the Heat of Evaporation, L, one has:

$$L = RT^2 \frac{\partial(\ln P)}{\partial T}$$

and this becomes:

$$L = \frac{RT^2 a'_1 x^2 + A'_p x(1-x) + a'_2 (1-x)^2}{a_1 x^2 + A_p x(1-x) + a_2 (1-x)^2}$$

where:

$$A'_p = \frac{\partial A_p}{\partial T} \quad \text{and} \quad a'_n = \frac{\partial a_n}{\partial T}$$

The Dimension Principle can also be applied to other properties, like Heat extension, Viscosity, etc.

For 1 Butene, n Butane -- for which Sage and Lacey gave experimental P-x and y-x values [Ind. Eng. Chem. 40, 1299 (1948)], one finds with:

$$b_1 = 0.00512 \quad b_2 = 0.0054 \quad B = 0.010496 \quad \bar{x} = 0.4518$$

$$A_1 = 0.09501 \quad A = 0.1654$$

so that

$$\text{at } 100^\circ\text{F:} \quad P = \frac{-0.00297x^2 + 0.01006x + 0.07767}{[0.000024x^2 - 0.00304x + 0.0054]^2} \quad y = \frac{-0.01025x^2 + 0.09501x}{-0.00297x^2 + 0.01006x + 0.07767}$$

---

<u>1 - Butene:</u> <u>x</u>	<u>P exp.</u>	<u>P calc.</u>	<u>y exp.</u>	<u>y calc.</u>
0	51.5			
0.3	55	55.1	0.337	0.34
0.5	57.4	57.3	0.537	0.58
0.7	59.6	59.6	0.728	0.74
1	62.5			

PHASE EQUILIBRIUM IN THE 1-BUTENE-WATER SYSTEM  
AND CORRELATION OF HYDROCARBON-WATER SOLUBILITY DATA

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University of Arkansas

The experimental data of this work determined the compositions of the co-existing phases in the liquid-liquid region of the 1-butene-water system in the temperature range of 130°F to 310°F and at pressures up to 10,000 psia. The experimental data are a continuation of the work of Brooks (6) who determined the phase behavior and compositions of the 1-butene-water system in the three phase region.

The data of this work have been compared with solubility data for other light hydrocarbon-water systems to illustrate the effect of molecular weight and structure upon the mutual solubilities. The effect of the double bond on solubility has been illustrated by comparing the data of this work with the data of Reamer, Sage, and Lacey (41) for the n-butane-water system.

Thermodynamic methods of interpolating and extrapolating solubility data for hydrocarbon-water systems have been investigated using the data of this work. It has been shown that for very dilute solutions a straight line should be produced by plotting  $\ln \left(\frac{f}{P}\right)$  against  $P$  at a constant temperature where the term  $\left(\frac{f}{P}\right)$  is the ratio of the fugacity of the solute to its mole fraction in the solution, and  $P$  is the total pressure of the system. The data of this work fit the predicted linear relationship well at pressures above about 2000 psia but show considerable deviation from linearity at lower pressures which approach the three-phase pressure.

It has also been shown that dilute solutions of structurally similar molecules should produce a straight line when constant pressure solubility data are plotted as  $\ln x$  against  $1/T$  where  $x$  is the mole fraction of the solute and  $T$  is the absolute temperature of the system. It was shown that water solubilities in the hydrocarbon-rich phase fit the linear relationship very well, but wide deviation from linearity exists for hydrocarbon solubilities in the water-rich phase.

A method has been proposed for estimating solubilities of water in light hydrocarbons from the volumetric and thermodynamic properties of the pure components. The method is empirical although it is based on the theoretical work of Scatchard (49) and Hildebrand (23). By making simplifying assumptions as to molecular structure it may be shown that the concentration of water in hydrocarbons may be represented as follows for very dilute solutions:

$$x_2 = \frac{V_1}{V_2} e^{-\left[1 - \frac{V_2}{V_1} \frac{V_2(c_{11} - 2c_{12} - c_{22})}{RT}\right]}$$

where  $x_2$  is the mole fraction of water,  $V_1$  and  $V_2$  are respectively the molar volumes of pure hydrocarbon and water, and the  $c$  terms are functions of the intermolecular forces between pairs of molecules.

The  $c_{11}$  and  $c_{22}$  terms which account for forces between pairs of like molecules are evaluated as follows:

$$c_{11} = \frac{(U_o - U_p)_T}{V_1}$$

where  $(U_o - U_p)_T$  is the change in internal energy for an isothermal expansion of the pure component 1 from the pressure and temperature of the system to zero pressure, and  $V_1$  is the molar volume of the pure component.

The  $c_{12}$  term which involves intermolecular forces between pairs of unlike molecules is evaluated empirically by methods suggested by the combinations of second virial coefficients in the equations of state of the pure components

which produce the second virial coefficients in the equation of state for a binary solution. The methods found to be most effective were a linear combination:

$$c_{12} = a(c_{11} + c_{22})$$

where  $a$  is an empirical constant found to be equal to approximately 0.26 for paraffin hydrocarbon solvents and about 0.29 for 1-butene.

And also a Lorentz combination:

$$c_{12} = \frac{1}{b}(c_{11}^{1/3} + c_{22}^{1/3})^3$$

where for paraffin hydrocarbons:

$$b = 25.50 + 19.24 T_R^{0.2} \left(1 - \frac{V_2}{V_1}\right)$$

where  $T_R$  is the reduced temperature of the pure hydrocarbon.

Using these methods solubilities of water in hydrocarbons may be estimated with average deviations of about 20%, and maximum deviations of about 70% of observed values. The constants were evaluated for liquid hydrocarbon solvents, and the calculated solubilities become more in error as the state of the solvent approaches that of an ideal gas.



ELEMENTARY CHEMICAL CALCULATIONS

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Chemistry as a mathematical science teaches an analytical approach to the solution of problems. This, we believe, carries over to other subjects and other situations. In solving chemical problems the student is taught to recognize the items which are given and those which are sought for. He is taught to bring to bear on the problem at hand the relationships among the quantities given and those to be found. One trained in this manner, when confronted with an unknown situation, will perhaps bring logic and organization to bear upon its solution.

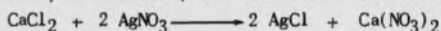
Let us be concrete and take a few illustrative problems and see how the student is trained to solve them. Let us take a very simple problem at first and discuss its solution.

How many grams of silver chloride can be obtained from 10.00 g of calcium chloride if the yield is 100 per cent?

There are two methods of approach. One is algebraic, involving ratio and proportion; the other arithmetical. In either case the problem must be analyzed in order that the given and the required be clearly recognized. As a first step in solving many problems, it is best to have the pupil write and balance the equation representing the chemical change. This step teaches the pupil the chemistry involved.

Later the reactions are many and complex in going from given to unknown, and therefore it is logical to teach the student to recognize chemical equivalents.

Solving the problem given above from the algebraic standpoint, one would proceed as follows. In the first step of writing and balancing the equation, any soluble silver salt may be selected, and the nitrate is used here.



The second step is to read the problem again and to place under the formula of the known in the balanced equation the amount given, and under the formula of the unknown the symbol  $y$ . This symbol is chosen to prevent confusion with the multiplication sign.

The units are always included. In the third step of the solution, the pupil is taught to write the correct multiples of the atomic or molecular weights of the given and required substances over the respective formula for each in the balanced equation. This would give



The fourth step is to point out to the pupil that if one molecular weight (110.99 parts by weight) of calcium chloride yields two molecular weights (2x 143.34 parts by weight) of silver chloride, then 10.00 g of  $\text{CaCl}_2$  will yield  $y$  g of silver chloride, or expressed as a proportion

$$\frac{110.99}{2(143.34)} = \frac{10.00 \text{ g}}{y \text{ g}}$$

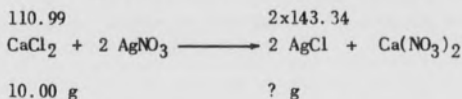
The proportion can be written also

$$\frac{110.99}{10.00 \text{ g}} = \frac{2 \times 143.34}{y \text{ g}}$$

In either case

$$y \text{ g} = \frac{10.00 \times 2 \times 143.34 \text{ g}}{110.99} = 16.82 \text{ g}$$

In the arithmetical procedure the steps are similar to the algebraic one except that a question mark is written under the unknown. The solution is to find the amount of unknown per unit amount of the known, and then the amount of unknown per given amount of the known. This is the procedure followed in solving arithmetical problems in the grades. Thus for the problem given above



then

$$\frac{2 \times 143.34}{110.99} \times 10.00 = 16.82 \text{ g of AgCl}$$

$\uparrow$                        $\uparrow$   
 Grams of              Grams  
 of                      of  $\text{AgCl}_2$   
 $\text{AgCl}$  per              per 10.00 g  
 g of                      of  $\text{CaCl}_2$   
 $\text{CaCl}_2$

The complete statement of the solution of the problem to a given point is indicated by the arrow. This type of procedure is better suited to the solution of more complex problems. Let us choose such a problem and follow its solution.

A sample of impure ferrous ammonium sulphate weighs 0.5013 g and furnishes 0.0968 g of  $\text{Fe}_2\text{O}_3$ . What is the percentage  $\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ ? (7).

In the solution of this problem it is best to use chemical equivalents. The student at this stage of training should recognize that one molecule or one molecular weight, respectively, of  $\text{Fe}_2\text{O}_3$  is equivalent to two molecules or two molecular weights, respectively, of ferrous ammonium sulphate. The solution then is as follows:

$$\frac{(2 \times 392.15 \text{ g})}{2 \text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2} \times \frac{6\text{H}_2\text{O}}{0.0968 \text{ g}} \times \frac{1}{0.5013} \times 100 = 94.8 \text{ Per cent ferrous ammonium sulphate in the impure sample}$$

$\uparrow$                        $\uparrow$                        $\uparrow$   
 Grams of ferrous      Grams of      Grams of      Grams of  
 ammonium sulphate      ferrous      ferrous      ferrous  
 per g of ferric      ammonium      ammonium      ammonium  
 oxide                  sulphate      sulphate      sulphate  
                             per 0.0968      per 100 g  
                             g of fer-      of impure  
                             ric oxide.      sulphate;  
                             This is      of impure  
                             the g of      sulphate;  
                             ferrous      sulphate      this is parts  
                             ammonium      phate      per 100 parts  
                             sulphate                       which is  
                             in the                       per cent  
                             sample of  
                             impure fer-  
                             rous ammo-  
                             nium sulphate.

Let us solve two other typical problems. A sulfuric acid solution has a density of 1.84 g per milliliter and is 96.0 per cent by weight hydrogen sulphate ( $\text{H}_2\text{SO}_4$ ). Calculate the molality, molarity and normality of the solution.

<sup>7</sup> Hamilton and Simpson, *Calculations of Quantitative Chemical Analysis*, second edition, McGraw-Hill Book Co., Inc., 1947, p. 128.

$\frac{96.0}{4.0}$	x	$\frac{1000}{98.02}$	x	$\frac{1}{98.02}$	x	244.8 m
↑		↑		↑		
Grams of $\text{H}_2\text{SO}_4$ per gram of $\text{H}_2\text{O}$		Grams of $\text{H}_2\text{SO}_4$ per 1000 g of water		Moles of $\text{H}_2\text{SO}_4$ per 1000 g of water. This is the molality		

$\frac{96.0}{100}$	x	1.84	x	$\frac{1000}{98.02}$	x	18.02 M
↑		↑		↑		
Grams of $\text{H}_2\text{SO}_4$ per grams of solution		Grams of $\text{H}_2\text{SO}_4$ per 1.84 g of solution, which is the grams of $\text{H}_2\text{SO}_4$ per ml of solution		Grams of $\text{H}_2\text{SO}_4$ per 1000 ml of solution		Moles of $\text{H}_2\text{SO}_4$ per 1000 ml of solution. This is the molarity

$\frac{96.0}{100}$	x	1.84	x	$\frac{1000}{49.01}$	x	36.04 N
↑		↑		↑		
Grams of $\text{H}_2\text{SO}_4$ per grams of solution		Grams of $\text{H}_2\text{SO}_4$ per 1.84 g of solution, which is the grams of $\text{H}_2\text{SO}_4$ per ml of solution		Grams of $\text{H}_2\text{SO}_4$ per 1000 ml of solution		Equivalent weights of $\text{H}_2\text{SO}_4$ per 1000 ml of solution. This is the normality

The freezing point of the solvent is lowered to  $-0.465^\circ\text{C}$  by the addition of 34 g of sugar in 400 g of water. What is the molecular weight of the sugar?

$\frac{34}{400}$	x	$\frac{1000}{0.465}$	x	$\frac{1}{1.86}$	x	340 Molecular weight
↑		↑		↑		
Grams of sugar per g of water		Grams of sugar per 1000 g of water		Grams of sugar per 1000 g of water for a depression of $1.86^\circ\text{C}$		This is the molecular weight

More complex problems may require analysis by parts. However, the parts may be fitted together to make a logical solution of the problem.

In more advanced chemical theory, neither the arithmetical nor the algebraic methods of solving problems will suffice. The solutions at these levels will require a knowledge of calculus, differential equations, or higher branches of mathematics.

We believe that the logical methods of reasoning developed in chemical calculations will carry over to other life situations and will stimulate a reasoned approach to the solution of problems in general.

THE USE OF SALES TAX STATISTICS IN THE  
STUDY OF ECONOMIC GEOGRAPHY

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Southern State College

Over a period of nearly two years, the writer studied the recreation industry in one of Michigan's northern cutover counties -- Alger County.<sup>1</sup> The study had two objectives: (1) to describe the recreation industry in its spatial setting and in terms of its individuality in Alger County, and (2) to ascertain the significance of the industry in the economy of the county. The latter involved, among other sources, the use of sales tax statistics. Inasmuch as the State of Arkansas also imposes a sales tax on retailers, it was thought that a discussion of the possible uses to which Arkansas sales-tax materials could be put might be of interest to geographers in Arkansas. Sales tax returns can be revealing as is shown by considering their use in the above-mentioned study.

Since its adoption in 1933, the Michigan sales tax has been imposed upon retailers of tangible personal property in Michigan at the rate of three per cent of their receipts from retail sales.<sup>2</sup> Each month the Michigan Department of Revenue issues a bulletin giving a summary of tax collections by counties and by kind of tax.<sup>3</sup> This information, along with unpublished sales-tax statistics obtained from the tax offices in Lansing, has proved to be a rich source for the student of recreation; a source largely untapped as of the year 1952.

A COMPARISON OF SALES-TAX COLLECTIONS  
FOR SELECTED COUNTIES

By plotting on graphs the monthly per capita collections for selected counties, one quickly perceives very significant differences in the seasonal pattern of retail sales between a tourist county (Alger) and other counties which one might characterize as agricultural (Clinton and Gratiot) or urban-industrial (Wayne). Figure 1 shows a sharp rise beginning with May for Alger County until the peak in sales is reached in the months of July and August which are the peak tourist and vacationing months. Collections fall off in September and October, but rise significantly again in November which is the deer-hunting season. It is interesting to note that the November sales-tax collections are higher than the December collections; the reverse of collections in the other counties pictured and for the state as a whole (see Figure 2).

On the other hand, Wayne County, which includes the city of Detroit, shows a much different curve; a curve with a significant drop in sales during the months of July and August, the same months which were the peak months in Alger County. In fact, sales dropped to the low levels of January. Although there are many factors involved in the economy of Wayne County which will not be considered here, certainly one important factor explaining this drop in sales is the fact that many thousands of people living in the county are vacationing and, therefore, spending elsewhere during this period.

The agricultural counties of Clinton and Gratiot are inland and lack significant bodies of water suitable for recreational development. Undoubtedly, business is stimulated by transient tourists, but this is probably balanced by expenditures outside the county borders by the inhabitants of those counties who are vacationing elsewhere.

SALES-TAX COLLECTIONS, ALGER COUNTY AND  
THE STATE OF MICHIGAN COMPARED

The writer has determined by months the percentage increase or decrease in sales-tax collections over or under the months of January, 1951, for both Alger County and the State of Michigan as shown in Table 1. By plotting these percentages on a graph as shown in Figure 2, it is possible to obtain a rough approxima-

<sup>1</sup> This paper is based in large part on the writer's Ph.D. Dissertation, *The Significance of the Recreation Industry in Alger County, Michigan*, University of Michigan, 1953, pp. 78-91.

<sup>2</sup> Retail Sales Tax, Act 167, O. S. 1933.

<sup>3</sup> *Monthly Bulletin*, Michigan Department of Revenue, Lansing, Michigan.

tion of the value of retail sales which can be attributed to the spending of tourists and vacationers in Alger County. January is used as the base month for the reason that it is the low month of the year for most kinds of business activity. February retail sales are smaller in value for the state as a whole, but this is attributed to the fact that February had three fewer days than January:

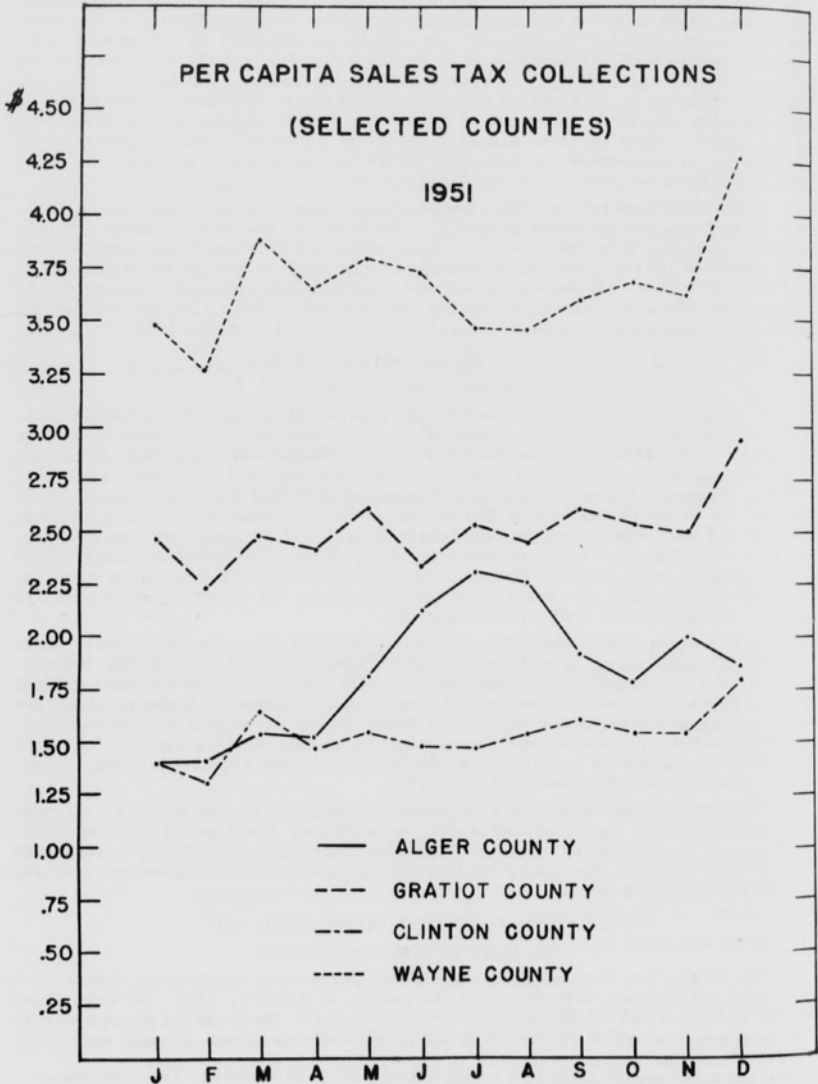


Fig. 1. -- Per Capita Sales Tax Collections, Selected Counties, 1951.

The intervals between the two curves allow one to determine on a percentage basis the amount of money spent in Alger County over and above the curve of Michigan retail sales for the months of May through November -- those months in which significant tourist and recreational activity is evident in Alger County. The percentage intervals for the designated months total 249 per cent. Two hundred and forty-nine per cent of January's sales (\$462,525.33) for Alger County is \$1,151,688.07. This sum divided by the total sales for the year (\$7,309,983) gives a figure of nearly 16 per cent. On this basis, it is estimated that approximately 16 per cent of the sales made by retail merchants in Alger County in 1951 could be attributed to the spending of tourists and vacationers, or to the spending of people who catered to the tourists and vacationers.

As far as the writer can determine, the great increase in retail sales during the recreation season is almost entirely the result of the influx of recreationists. The manufacturing plants of the county operate the year around without letup. According to persons intimately associated with the farm economy of the county, the peak sales in various farm products occur in the spring, fall, and winter months when the recreation industry is not at its peak. Wood-cutting operations extend the year around and do not vary greatly except in the months of April and May when the state-imposed load limits on trucks reduce operations to a near halt. Expenditures by commercial fishermen may contribute somewhat to the increase in retail sales during the warm months when fishing is possible on Lake Superior, but much of the activity of fishermen in the months of May through September is connected with sport-trolling; a recreational activity. It would appear, therefore, that nearly all of the increase in retail sales during the recreation season can be attributed to the recreation industry.

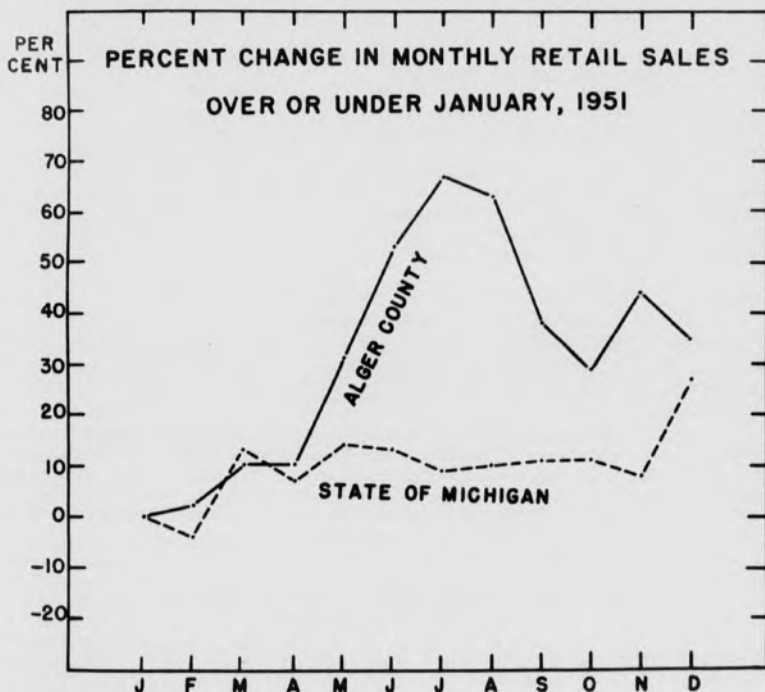


Fig. 2. -- Per Cent Change in Monthly Retail Sales Over or Under January, 1951, Alger County and State of Michigan.

TABLE I  
 PERCENTAGE INCREASE OR DECREASE OF MONTHLY  
 SALES-TAX COLLECTIONS OVER JANUARY, 1951  
 ALGER COUNTY AND STATE OF MICHIGAN COMPARED

Month	ALGER COUNTY		MICHIGAN	
	Total Sales Tax Collections*	Per cent increase or decrease over January	Total Sales Tax Collections*	Per cent increase or decrease over January
Jan.	\$13,875.76	.00	\$18,164,511.61	.00
Feb.	14,170.10	.02	17,388,162.55	-.04
March	15,194.48	.10	20,430,118.10	.13
April	15,207.08	.10	19,467,126.97	.07
May	18,244.20	.31	20,666,526.00	.14
June	21,190.83	.53	20,483,325.45	.13
July	23,107.82	.67	19,835,011.67	.09
August	22,556.40	.63	19,947,762.72	.10
Sept.	19,195.40	.38	20,131,170.96	.11
Oct.	17,870.87	.29	20,203,878.10	.11
Nov.	19,995.41	.44	19,614,815.58	.08
Dec.	18,694.16	.35	22,995,486.87	.27

\*Source: Monthly Bulletin, issues of 1951, Michigan Department of Revenue, Lansing, Michigan.

Indirectly the economic significance of the tourist and recreation industry on retail sales is much greater than indicated by the figures, 16 per cent or \$1,151,688.07. Some of the inhabitants of Alger County could not live in the county if it were not that a portion of their income came from the tourist and recreation industry, and, therefore, their existence in the county, as well as that of the service establishments meeting their needs, is to a considerable degree dependent upon the tourist and recreation industry.

#### THE EFFECT OF THE TOURIST AND RECREATION INDUSTRY ON SELECTED TYPES OF BUSINESS ACTIVITY

Monthly sales tax collections for various kinds of business activity can be plotted on graphs, and from such graphs, Figure 3, one can readily see the influence which the tourist and recreation industry exerts on these types of businesses.<sup>4</sup>

It can be inferred from Figure 3 that many eating establishments in Alger County owe their existence to tourists and vacationers. There is a striking increase in business during the summer tourist season and also during deer season in November. Restaurant sales-tax collections and, therefore, restaurant business for the month of August is 230 per cent greater than for either January or April.

Many other types of business activity are greatly affected by the influx of tourists and vacationers. Notable among these are drug stores, liquor stores, sporting goods stores, grocery stores, and filling stations as is shown by Figure 3. These businesses supply the immediate needs or desires of the tourist and vacationer and, therefore, reflect the influx of tourists and vacationers more than businesses which satisfy long-time needs. It is interesting to note that November, deer season, is the peak month for liquor sales in Alger County. Certain types of businesses such as department stores and general merchandise stores are similarly affected during the tourist season, but only moderately so. The sale of dairy products by farm dairies remains unchanged and does not reflect demand, but rather the supply of milk which is produced by a more or less fixed number of cows.

<sup>4</sup> Taken from unpublished figures in the files of the Sales Tax Division of the Michigan Department of Revenue, Lansing, Michigan.

In the cases of restaurants, drug stores, taverns, and filling stations more than fifty per cent of the year's sales occur during the recreation season -- that is during the five months from June through November.

Yet another approach using sales tax statistics is used in Table 2. Four types of businesses are considered: filling stations, taverns, restaurants, and grocery stores. The number of establishments in the State of Michigan in each group is divided into the 1950 population of the state, and a figure for the average number of people per establishment in each group is secured. The same is done for Alger County. Immediately it can be seen (Table 2) that Alger County has an excess of establishments in all four categories if the state averages are accepted. By dividing these state averages into the population of Alger County, one arrives at the number of establishments in each group which might be found in the county if Alger were characteristic of the state as a whole.

By subtracting the latter figures from the actual number of establishments in each group found in Alger County, it is possible to arrive at the number of excess establishments found in each group. By this process, it is found that there are 64 excess establishments out of a total of 126 establishments in the four groups or, in other words, slightly over 50 per cent of the establishments in these groups might be said to owe their existence to the recreation industry. This was substantiated to some degree by personal observation in Munising, the county seat, during the month of January. Of the ten restaurants serving tourists and local people in the summer, only five were open. More striking is the fact that only one motel out of a total of fifteen was operating.

Table 2  
EXCESS ESTABLISHMENTS (SELECTED KINDS OF BUSINESSES)  
IN ALGER COUNTY

Type of Business	Number of People per Establishment (Michigan)	Number of People per Establishment (Alger County)	Number of Establishments (Alger County)
Filling Station	617	357	28
Taverns	931	360	27
Restaurants	656	286	35
Grocery Stores	613	278	36

Type of Business	Number of Establishments That Would Be In Alger County On Basis of State Averages	Number of Excess Establishments in Alger County
Filling Stations	16	12
Taverns	11	16
Restaurants	15	20
Grocery Stores	20	16
	<b>Total</b>	<b>64</b>

SOME SUGGESTED USES TO WHICH ARKANSAS SALES TAX  
FIGURES MIGHT BE PUT

The above is only a small indication of the possibilities which sales-tax statistics hold for the study of Arkansas. For example, little is known about the incomes of Arkansas citizens -- that is, how income varies from one part of the state to another. It would be possible through the use of sales-tax statistics to determine the sales tax paid on a per capita basis in each county. These figures could well be mapped and a very clear picture of the variations in in-



comes would be shown. The results would be far superior and far more intelligible than the state per-capita income figures given us by the United States Department of Commerce. The sales tax is levied on consumer goods and gives a far better picture of the ability of people to buy consumer goods.

By plotting sales-tax statistics on graphs, it is also possible to show seasonal variations in retail sales by counties as a whole, or by types of business in each of the counties. These seasonal variations should be subject to mapping. Such maps and graphs, along with our present knowledge of the economies of the several counties, would allow for a better appraisal of the economic geography of the state as a whole.

It should be possible to characterize counties by the use of such evidence as being agricultural (perhaps by kinds of crops), industrial, forest, tourist, or as being combination counties of these and other activities. There would undoubtedly be major differences in per-capita incomes and in seasonal retail sales between such counties as Mississippi (a cotton county), Pulaski (an urban county) and Garland (a recreation county). We could better relate economic conditions to the natural environment by such methods. The significance of climatic conditions was strikingly apparent in the above-mentioned study of retail sales in Alger County, Michigan.

Another topic of interest would be the effect of Arkansas taxes and the taxes of bordering states on the location of various types of businesses in areas bordering our state lines. The retail sales of Arkansas counties bordering on the state line would undoubtedly differ from the retail sales of counties located in the interior of the state.

CONCLUSION

A great deal more use of such statistics is possible than has been suggested above, but the purpose of this paper has been served. It is clear that sales-tax statistics have much to offer to geographers who are interested in further understanding the economic geography of Arkansas.

SALES TAX COLLECTIONS  
BY TYPE OF BUSINESS  
ALGER COUNTY 1951

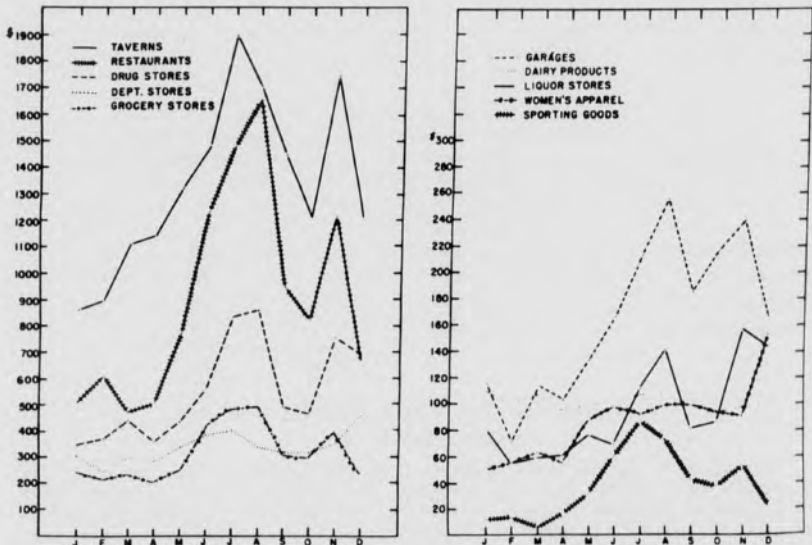


Fig. 1. Sales Tax Collections by Type of Business, Alger County, Michigan

## URBAN LAND CLASSIFICATION

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The Housing Act of 1949, under Title I, enables communities to obtain financial aid from the federal government for slum clearance and redevelopment programs. Under the act, four types of areas qualify for redevelopment aid. The act describes them this way:

1. Blighted residential: A slum area or a deteriorating area which is predominantly residential in character.
2. Blighted area not predominantly residential: A deteriorated or deteriorating area which is not predominantly residential in character.
3. Predominantly open land: The major portion of the area in question is not improved with buildings or other structures.
4. Open land: Whether platted or unplatted, which has not been developed by the provision of streets, utilities, site improvements or buildings.<sup>1</sup>

A blighted residential area may be redeveloped for any appropriate use, while the other three areas must be redeveloped for predominantly residential uses only.

The meaning of the term "residential in character" poses an administrative problem, as the interpretation of this phrase will determine how the area may be redeveloped. In spite of the weight that the phrase carries in the act, it is not defined. This paper attempts to define the phrase "residential in character" and show its relation to other urban land uses.

The earth as a whole, with the land considered to be the crust of the earth, has three general classifications:

1. Surface land: Agricultural, forest, land for transportation and communication, urban, and unutilized or barren land.
2. Water.
3. Subsurface minerals.

Urban land, the main concern here, is classified most satisfactorily according to its specific uses, which in turn are dependent on physical and economic conditions. A classification may be developed this way:

1. Publicly utilized land.
2. Privately utilized land: Industrial, commercial, and residential.
3. Unutilized land: Vacant and open.

Publicly utilized land can be distinguished from other land quite easily although it cannot be found as a separate division of the urban area. That is, it is everywhere in the urban area where land is being used for streets, transportation facilities, utilities, schools, libraries, parks, playgrounds, and hospitals which are located in both residential and commercial areas.

Public utilities such as garbage disposal, sewage treatment plants, and power plants usually are forced to satisfy their land requirements in the industrial area.

Land utilized by industry in the urban area can be identified easily as a separate part of the city. Its particular location is due to physical and economic conditions, and perhaps to some extent by public pressure. Industry favors flat land which requires a simply constructed foundation. Swamp or marsh land, although flat, is usually not stable enough to support heavy machinery and buildings on a simply constructed foundation. Industry today, however, will go to the expense of suiting swamp land to their buildings rather than locating on rough topography. The flat land favored by industry is served by railway, water ways (when possible) and highways of minimum grade. Public pressure or laws will force industry to stay in its part of the city because of its undesirable characteristics -- smoke, noise, odors, high tension electric lines, heavy transportation facilities, and other nuisances.

<sup>1</sup> U. S. Housing and Home Finance Agency. Office of the Administrator. *Slum Clearance and Urban Redevelopment Program*. Book I (Parts 1 and 2) *Local Public Agency Manual*. Washington: Government Printing Office, 1954, Part 2, Chapter 3, pp. 3, 4, and 5.

Commercial establishments also favor flat or nearly flat ground, but they do not require the extensive heavy transportation facilities nor the storage space so essential to industry. Therefore, in general, it occupies land on the outskirts of the industrial area and grows in the same direction as the residential area. Competition for favorable locations in the commercial area usually increases land value to the extent that other uses are eliminated or economically prohibited. In recent years, the mounting cost of favorable locations has forced some commercial establishments to leave the central commercial area, and to develop outlying business centers at the intersection of main highways and other potentially desirable locations where the land is considerably cheaper and there is no parking problem.

Land utilized for residential purposes has a wider variation in topography than that used by commerce or industry. The most favorable residential location is high ground which has utilities and transportation facilities accessible. The most undesirable land is low-lying land, subject to flood or requiring special sewage facilities, or land which abuts an industrial area, a commercial area, a railway line, or another such physical barrier. Since such a large portion of the urban area is used for residential purposes, only the ability to pay will determine whether a person lives on desirable or undesirable residential land.

Unlike commercial and industrial land, residential land has no characteristic type of topography. Thus, the residential characteristics of an area can be determined only from man-made changes in the land, the use that is made of the land, the type of structure placed on it, and the surrounding influence.

The Slum Clearance and Redevelopment Manual indicates that "residential in character" means, first, that the land is being used for dwellings and such necessary facilities as schools, churches, health clinics, parks, and police and fire services; second, that the structures on the land were built for dwellings and have been maintained as such. The Manual notes that the Division in Washington will decide what is residential in character without further definition, thus leaving the reader without a definition and leaving the mistaken impression that land must have a dwelling or an incidental neighborhood use in order to have residential character. Therefore, according to the Manual, a vacant lot, no matter what its surroundings, belongs in the category of open land. This should not be so, because every lot in a residential area has the same characteristics as the rest of the area, whether or not it has a dwelling on it. The land has, in general, been platted, recorded, and sold for residential uses. The streets are generally narrow, with pavement designed to carry only local traffic. All utilities -- water, sewerage, gas and electricity -- have been designed to serve the needs of a residential neighborhood. Every lot is taxed to provide police and fire protection, schools, parks, and recreation areas for the neighborhood. There is usually access to a transportation system and the area is, in general, free from hazards and nuisances. Vacant lots in a residential neighborhood possess the same characteristics as an occupied lot with the exception of having a residential structure. In short, if a neighborhood has begun to develop as a residential area, the term "residential in character" should apply to all of it and not just to lots with residential structures on them.

Unutilized land is somewhat like publicly utilized land in that it may be found anywhere in the urban area. Probably it does not belong in a class by itself, except for the purpose of description.

Unutilized land, although the Manual classes all such land as "open land," is usually divided into two classes -- vacant and open land. Vacant land is actually in the nature of semifinished producers' goods or partially processed raw material intended for combination with a structure to create the finished commodity ready for use.<sup>2</sup> Therefore, it should be classified according to its location. That is, vacant land in a residential area would be classified as residential land, in a commercial area it would be classified as commercial land, and in an industrial area it would be classed as industrial land because once a few lots in any subdivision have been put to use the entire plot crystallizes, resists revision in plan, and is not readily subject to the correction of mistakes and deficiencies.<sup>3</sup>

Open land may be considered as land which is uneconomical to utilize or is not likely to be utilized. Such land would include swamp, solid rock, land left as a buffer zone, the face of very steep hills, and land laid waste by surface mining.

<sup>2</sup> Ratcliff, R. U.; *Urban Land Economics*, 1949, p. 165.

DELIMITATION AND ANALYSIS OF THE CENTRAL BUSINESS DISTRICT  
OF LITTLE ROCK, ARKANSAS

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The trade function of cities, although divided among a number of types of centers in the "city retail structure",<sup>1</sup> is most highly developed and most concentrated in what has come to be known as the Central business District. This district, which hereinafter I shall take the liberty of calling by the short designation of CBD, is not all the retail structure of the city, but it is its core. An understanding of the CBD is essential to an understanding of the trade structure of the urban region. When weighing our knowledge of commercial patterns within the city, we may well use our knowledge of the CBD as a touchstone. Geographers have for some time used the term central business district when discussing urban land-use patterns, but have they used it on the basis of knowledge or of conjecture?

Several years ago, a thorough investigation of the literature and work of urban geographers, in which the author participated at Clark University, resulted in the conclusion that the CBD was a name rather than a well understood feature in our profession, and for that matter in those other groups concerned with urban studies. This was a conclusion that has much wider application than to the CBD alone. In urban geography indefiniteness, lack of qualitative evaluation, and absence of broadly applicable measures are serious weaknesses. In part to establish standard measures, tested techniques of research, and broad standards of urban land use, and in part to learn more about this core of urban trade, Raymond Mughpy at Clark organized a full-scale investigation of the CBDs of American cities.<sup>2</sup> From this project detailed information was obtained on the CBDs of nine cities widely distributed among the major geographic regions of the United States,<sup>3</sup> and also a general picture of the characteristics of the CBDs of very nearly all American cities with an urbanized-area<sup>4</sup> population of 150,000 to 250,000.<sup>5</sup> I should like to utilize our previous work as a base for a consideration of the CBD of Arkansas' primary trade center, Little Rock. This application is facilitated by the general plan of the original project: to develop techniques of delimitation and analysis that may be applied in studying cities of comparable size so that those studies will yield a body of data susceptible to regional comparison.

DELIMITATION TECHNIQUE

The commercial core has been studied in most of our larger cities. In fact the planning reports that have been produced for our larger urban places usually establish such a district. However, anyone familiar with this planning literature will be aware of the impossibility of comparison among these districts. To illustrate this difficulty of judging one city's commercial area in relation to that area in another city we might well consider two extreme examples. The planning department in Worcester, Massachusetts has conducted a thorough study of the local CBD and, on the basis of land values, has delimited a district that comprises around ten normal-size blocks. Against this very restricted concept we may place the CBD that the planning department in Denver conceives for that city. The Denver CBD is drawn by the local planners to include several hundred blocks,

<sup>1</sup> Proudfoot, N. J., "City Retail Structure", *Economic Geography*, Vol. 13, 1937, pp. 425-428.

<sup>2</sup> The author had the opportunity to participate in this project and to serve as its principal field investigator.

<sup>3</sup> Worcester, Massachusetts; Roanoke, Virginia; Mobile, Alabama; Grand Rapids, Michigan; Tulsa, Oklahoma; Salt Lake City, Utah; Tacoma, Washington; Sacramento, California; Phoenix, Arizona.

<sup>4</sup> Urbanized areas as defined in the 17th U. S. census, 1950.

<sup>5</sup> A series of three articles presenting the conclusions of the study will be published in *Economic Geography*, Vol. 30 (July and October, 1954, January, 1955.)

using criteria that lump all non-residential uses as central business. Although Denver is slightly more than twice as large as Worcester, is a much more important trade center, and is a growing city in contrast to the static nature of the New England city, it seems doubtful that Denver and Worcester are actually so radically different in CBD development. I do not wish to question the accuracy or the usefulness of these planning studies. For the city concerned these studies are usually invaluable. However, for the student who desires to gain a picture of the CBD as a common functional area in American cities, it is virtually impossible to use such locally oriented studies.

This disparity in criteria and in delimited CBDs that exists in American cities led us to conclude that any understanding of the general nature of these districts would require as a preliminary step the establishment of standardized criteria for the delimitation of uniformly based CBDs. After much experimentation and field testing, we arrived at a program of mapping and statistical analysis that we believe yields satisfactory districts in diverse geographical regions, cities with different functions, and cities of varying size. I wish now to present a summary of this technique for CBD delimitation and then to proceed to its application to Little Rock.

After much trial and discussion, it was decided that land use provides the most generally applicable measure for the delimitation of CBDs. This decision did not intend to suggest that land use provides the only measure, but rather that the other measures, such as land value, trade indices, rent indices, pedestrian flow, and others, are extremely difficult to apply over a wide range of cities. Often the basic data are not available, and if available are seldom consistent among all cities. Land use, in distinction to the other measures, is available on a uniform base to anyone who is willing to engage in the necessary field work. By establishing a set technique for land-use mapping and use classification, we were able to secure a set of land-use maps that were susceptible to comparison.

Briefly stated, the mapping technique was established in three stages. The first stage was determining which of the multitude of central uses were truly central business as distinguished from adventitious uses found in the CBD. I cannot at this time present a full break-down of the hundred-odd land uses commonly found in the CBD. Broadly speaking, the central-business uses were those of retail trade, service trades, and most of the office uses that deal with the ultimate customer. Certain uses commonly found in the CBD were excluded by the definition that central business is business which is oriented toward serving the entire trade area of the city and all economic, social, and ethnic segments of that trade area population. Thus, ethnic shopping centers, which characterize many cities of the north and west were excluded as were the institutional types of offices, such as oil-company headquarters, telephone-company exchanges, insurance-company home offices, and other office industries. In the same way, the definition excluded wholesaling because it deals with a restricted patronage; governmental land uses because they are not business in the usual conception of that term; fraternal and other restricted membership organizations for the obvious reason that they are not open to all; and finally, manufacturing because its location in the CBD is quite often determined by the morphology of the city rather than by any site requirements.

Once having established the line between the sheep and the goats of the CBD, the second stage was that of developing mapping techniques for these two land-use classifications. Here a weakness of many existing studies had to be avoided --- their two-dimensional nature. That is, they present a picture of first-floor use alone. The CBD as a functional district of the city is, more than any other district, characterized by height. To exclude a consideration of height, in our minds, destroys much of the value of existing studies. But to map the CBD in three dimensions is not easy. Anyone who has engaged in field mapping realizes that three dimensions are almost impossible to record accurately on a single map, yet the field mapper cannot easily handle several maps in the course of his labors. To overcome this operational difficulty, we settled on the use of profiles. These profiles can be constructed prior to going into the field, using lot-line maps with a scale of two hundred feet to the inch. These are rather generally available for cities. The X-axis of the profile can be laid off from the information available on the lot-line maps so that the building lines are established.

In the field it is an easy matter to determine the Y-axis value by observation, simply by counting stories. To simplify our work, we settled on a uniform height for stories, concluding that excessively high floors were essentially no more useful than the average height of 8 to 10 feet.

On the profiles of land use, once having established the X and Y values, there was a grid of small block on which it is possible to record the various uses. The use classification established in stage one was then applied to the establishments found in the city, and when the work was completed in the field the result was a set of profiles which had two uses: first, to separate the central business from all other uses, a separation that had height as well as areal extent; and second, to set down a detailed picture of the hundred common land uses of these districts.

The third stage in the mapping technique was that of transferring the profile data to a set of land-use maps for each story. For convenience, and on the basis of observation that land use does not usually change above the second floor, all use above the second story was generalized on a single upper-story map. Thus, the culmination of the mapping techniques was the production of a set of three height-divided land-use maps.

With a detailed picture of the existing uses within the central part of the city based on a standard classification of these uses, we possessed a foundation on which to delimit the CBDs of a number of cities. However, a foundation does not become a structure without some plan, and there was no existing plan for delimiting the CBD in a number of cities. Experimentation with the many techniques which have been established by planners for setting off the CBD, and with those which we could visualize as offering a possible measure, led to the adoption of a dual yardstick. The two criteria may be called the Commercial-Space Index and the Commercial-Intensity Index. The use of two criteria seemed desirable to avoid including land that had a single tall building in central use in the midst of a large area of non-central use, or land that had a large area of central use but an extensive utilization of this area.

In applying these criteria it was necessary to decide what magnitude of area would be considered the basic unit. The two alternatives of any importance were the lot and the block. The lot offered a detailed and sensitive unit for delimitation, but it also suffered from the difficulties of not being a uniform and readily recognizable unit for individual workers, and of producing a very discontinuous CBD with many enclaves and exclaves. The block forms a unit that is not so accurate a base for the CBD, but one that is obvious to all workers in urban areas. It tends to result in the delimitation of a continuous district. For these reasons, considering fully the lack of sensitivity, we decided on the use of blocks as the unit for computing the two criteria.

The criteria themselves deserve some discussions. The Commercial-Space Index is essentially a measure of the difference in absolute development of central business. It is merely a reduction of the total central business space<sup>6</sup> within a block to an index number. This is done by dividing the central-business space by the ground area of the block. Thus, a block with 200,000 square feet of central business space and a ground area of 50,000 square feet would have a Commercial-Space Index of 4.00. The conversion to index figures facilitates the comparison of blocks of differing size.

The Commercial-Intensity Index might be called the measure of the relative importance of central business within the block. It is an index figure derived from the division of the central-business space by total space within the block. Thus, a block with 200,000 square feet of central business and a total space in all uses of 400,000 square feet would have a Commercial-Intensity Index of .50. This conversion facilitates comparison of blocks with different ground areas.

Experimentation and observation of the relationship of index values to obvious CBD blocks, to marginal CBD blocks, and to obviously non-CBD blocks resulted in the adoption of two crucial values of these indices. These crucial values separating CBD blocks from non-CBD blocks were 1.00 for the Commercial-Space Index and 0.50 for the Commercial-Intensity Index. All blocks with indices at or exceeding these values were considered to be part of the CBD whereas all blocks that failed to reach these crucial values in one or both the indices were excluded from the district.

<sup>6</sup> Space includes the ground area of the block with all floor-space in upper stories to give a total area available for use within the block. Thus space means all area that is available for any use.

ADJUSTMENTS OF THE PRELIMINARY DELIMITATION

The two delimiting criteria, when applied to cities on a block-unit basis, resulted in a generally satisfactory delimitation of CBDs. By satisfactory I mean both with regard to subjective cross-checking, an operation that is both necessary and we believe defensible when working in a humanistic rather than a physical scientific field; and with regard to the utility of the resulting delimited district. Obviously, in analysis it is necessary to find a measure of central-business concentration that, when applied, produces an analysis unit that conforms to the well-accepted and demonstrable peripheral gradation of CBDs outward from a center or peak point.<sup>7</sup> To use a CBD measure that resulted in a stringy or dissected district when such was not the observable characteristic of the district would be falling prey to the common beast of scholarship, allowing statistical objectivity to overcome utility and reason.

With four minor exceptions, the preliminary delimitation of the CBD through use of the two indices was satisfactory. To overcome these classes of problems it was necessary to adopt special rules covering the exceptions. Briefly stated these rules covered: (1) the exclusion of the few enclaves of central business near the CBD, (2) the inclusion of the few enclaves of non-CBD blocks, (3) the inclusion of most governmental land-use blocks, and (4) the inclusion of most blocks partially covered by governmental uses. I shall not take the time today to outline these rules, but rather shall satisfy the requirement of honesty by citing the fact that the delimitation technique used required those minor adjustments to produce a homogeneous and continuous CBD. As in the case of the delimiting indices, the rules were applied uniformly so the resulting districts in the cities studied were delimited on a consistent base.

THE CENTRAL BUSINESS DISTRICT OF LITTLE ROCK

The application of the mapping and delimitation techniques to Little Rock results in the establishment of the CBD shown on Figure 1. In general outline, this is the area bounded on the north by the Arkansas River; on the east by Scott Street; on the south by two-block sections of 8th Street, 7th Street, and 6th Street respectively between Scott and Broadway; and on the west by Broadway with one block deviations to either side thereof. The resulting district comprises 33.5 blocks with approximately 70 acres, or a volume of more than 52 million cubic feet. Within this area the mean value for the Commercial-Space Index is 1.73. This may be interpreted in another way as representing an average density of central business equal to a uniform covering of all ground area within the district to a height of one and three quarters stories. The mean value of the Commercial-Intensity Index for the whole CBD is .75, which again may be interpreted as representing three-quarters of all available space in central business.

When we consider these mean values as brought out in Little Rock, the distinction between the CBD of a city and its outlying business areas becomes more sharp than would be the case on a straight land-use basis. In the first place, the size of the district contrasts markedly with any other commercial area within the urban complex. No other business district would aggregate so much as 70 acres. Another sharp contrast is that in height. In general, commercial development outside the CBD is notably one story in character, and particularly so when the mean value of height is used. The commercial intensity shows far less contrast between central and outlying districts -- in both, the percentage of space in business is great. However, the combination of these three measures serves to distinguish central business districts from outlying districts.

In establishing the CBD of Little Rock, several unusual situations were encountered. Little Rock is one of only two cities (the other being Sacramento) out of the ten studied that contained an enclave of non-CBD blocks totally surrounded by CBD blocks. The two adjacent blocks that failed to satisfy the minimum criteria were included under the application of the special rule covering surrounded non-CBD blocks. Again Little Rock was exceptional in the matter of governmentally used blocks. The concentration of municipal and county buildings at the northwest of the district extended the boundary in a jog in that direction.

The district established through the indices and the application of the special rules, which is shown on Figure 1, is characteristic in shape for a city

<sup>7</sup> The peak point is the place within the CBD where the greatest focusing of pedestrian flow is found. Usually this point is surrounded by the highest land values in the city.

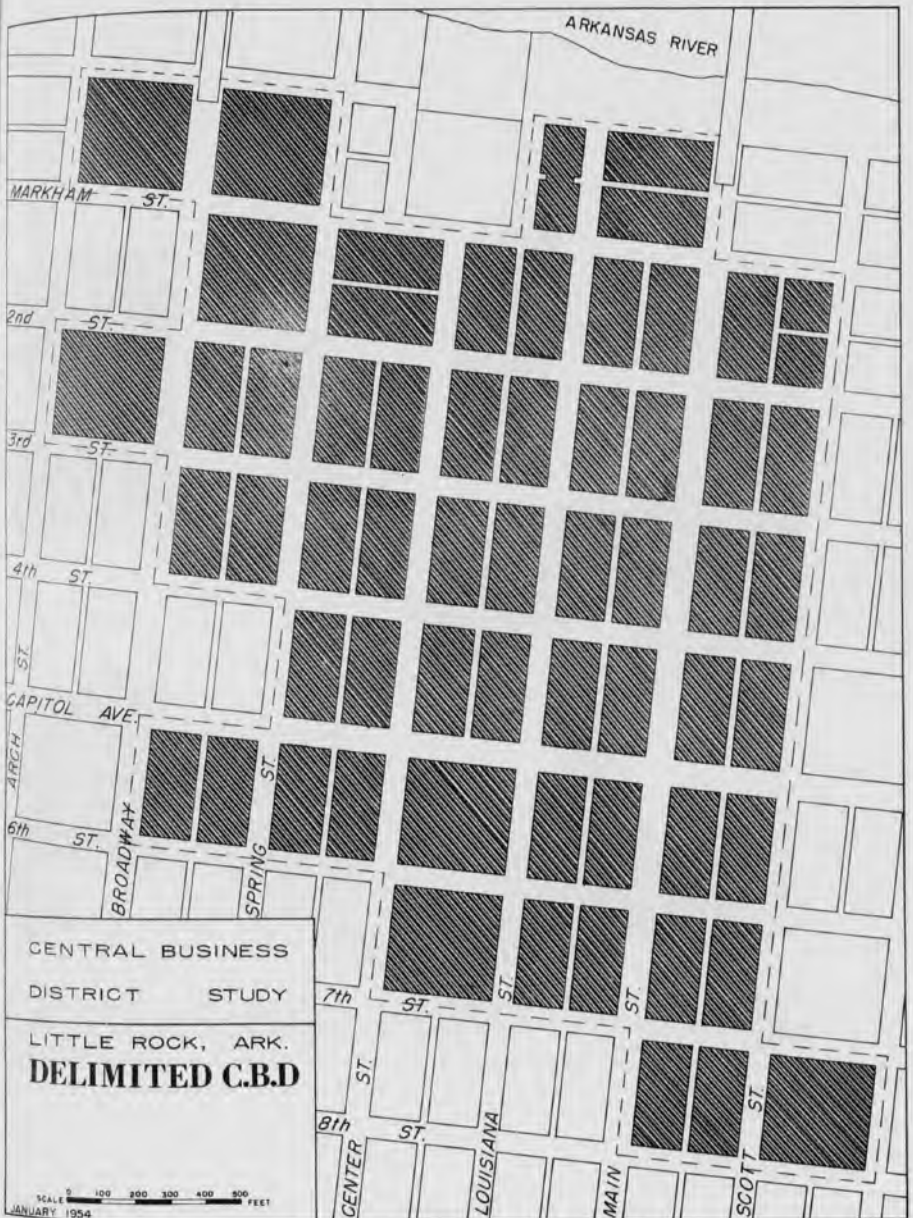


Figure 1



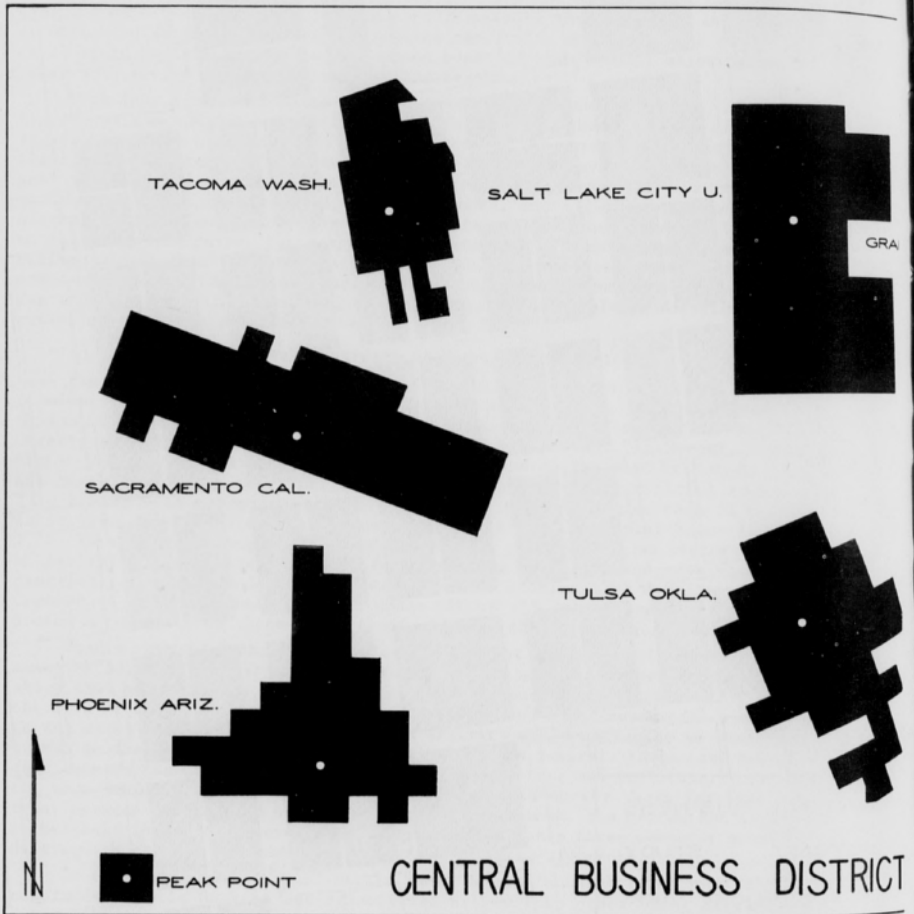
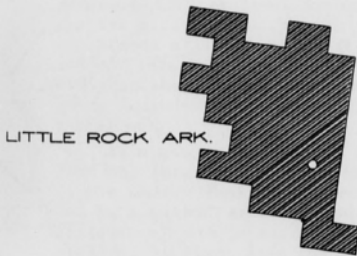
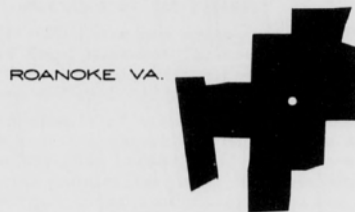
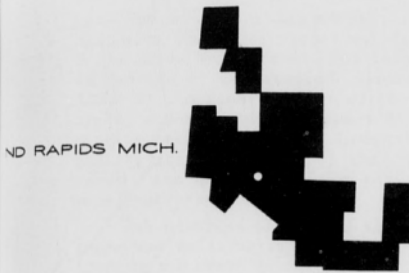


FIGURE TWO



S OF TEN AMERICAN CITIES ALL CBD'S AT UNIFORM SCALE AND ORIENTATION

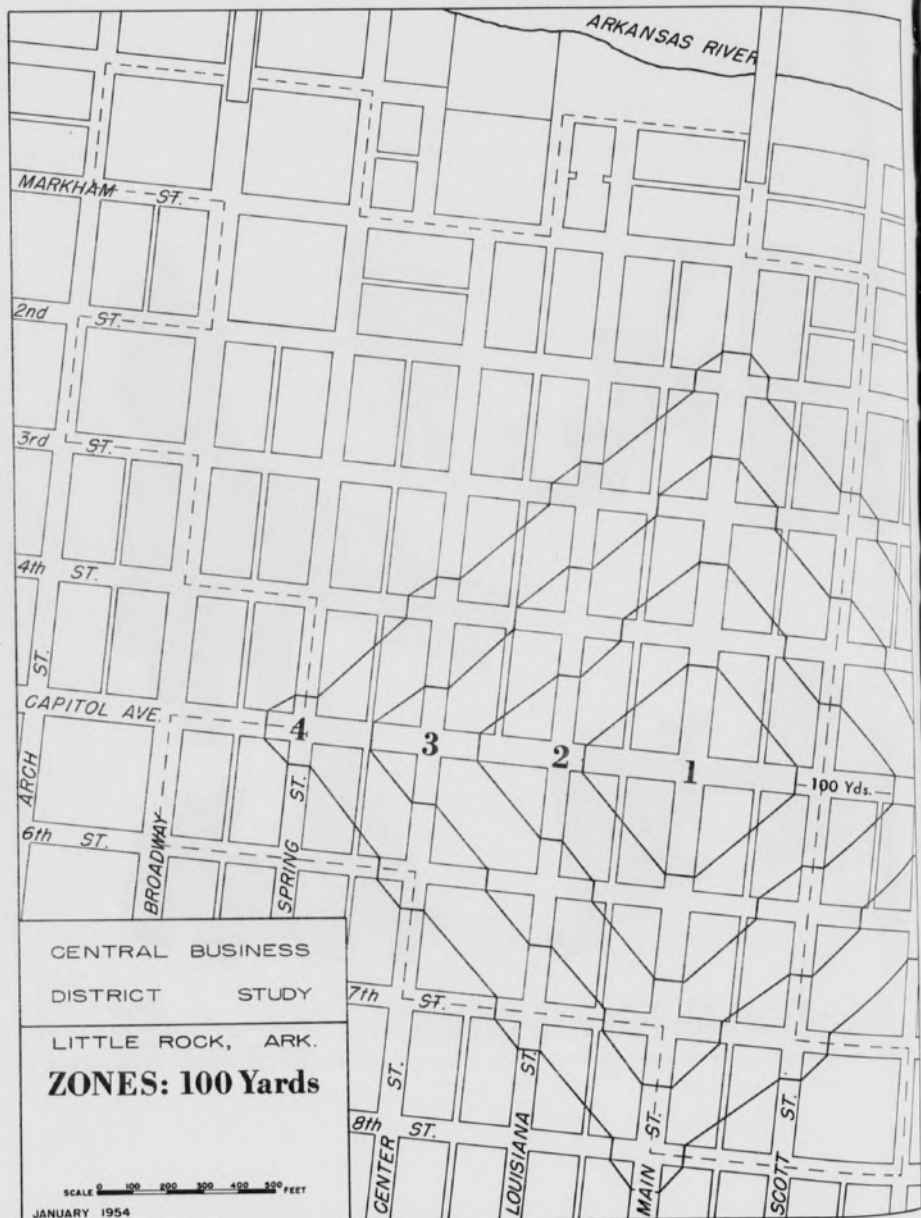


Figure 3

with a regular grid pattern of streets. Such a street pattern tends to result in the formation of a CBD with a generally rectangular outline, having as a boundary a jogged or saw-tooth edge. This outline contrasts sharply with the shape in the older random-patterned cities of the Northeast. There the outline usually is one of a major street and its bordering blocks, as shown on Figure 2.

A final general comment on the CBD of Little Rock -- that of overall size -- deserves mention. Reference to Figure 2 will bring out the relative size of the local CBD. Although Little Rock is the second smallest of the cities studied (only Roanoke is smaller), it possesses a CBD larger in area than that of the largest city studied -- Worcester, a city exactly twice as large as Little Rock. This relative size appears to be due to three factors: that Little Rock is a major trade center quite far removed from other cities of major size, that Little Rock is the centrally located capital of the state; and that Little Rock is more a new western-type city than an old eastern city.

The most striking anomaly in Little Rock is the lack of symmetry in the district. The major street within the CBD is Main Street and the peak point of focus is on Main Street. For this reason, Little Rock is the most asymmetrical of the ten cities studied. Explanation for this one-sidedness may possibly be found in the reorientation of the city. It is a rather generally accepted principle, and our studies support it, that the CBD tends to grow toward the highest quality residential area. In Little Rock there has been a movement of this high-quality area from south of the CBD to west of the CBD. If this be the causative factor, the asymmetry of the district west of its major thoroughfare is somewhat more understandable.

Two detailed aspects of the Little Rock CBD deserve special attention -- the types and relative importance of central business found, and the differences in location of these business types.

#### THE TYPES AND RELATIVE IMPORTANCE OF CBD BUSINESS

Within the area of the Little Rock CBD there are approximately 400 retail and service trade establishments. This total does not include the many offices that roost about the CBD, and it excludes the only office use that commonly is found on the ground floor, the insurance and real estate office.

The district contains at least one example of all but six of the 65 different types of central business that we have encountered in mapping ten American cities. Thus, it seems appropriate to say that Little Rock possesses a fully-developed CBD, at least for cities in its population class. No doubt our metropolitan cities would furnish business types found in none of these ten cities, but places of similar size to Little Rock do seem to have very nearly the same range of retail and service establishments. This, in fact, is one of the striking features that can be noted among our cities -- that the goods offered and the goods demanded seem to have essentially a national character rather than a regional one.

As might be anticipated from the broad nature of the class, service trades form the largest single group of establishments, with 69 units (17.4 per cent of the total). Ranking in second place is the food group, including restaurants and bars, with 63 establishments (15.9 per cent). The third largest group, clothing stores, with 58 establishments (14.4 per cent), might be considered most important, at least from the viewpoint of attraction. The fourth group, and the only other group to be dominant in size, is a catchall, miscellaneous retail which includes such establishments as jewelry stores, book store, pawn shops, etc. In Little Rock this group includes 51 establishments (12.9 per cent). The ranks behind these top four include all other classes of commerce in the following order: household, automotive, variety (department stores, drug stores, and Five and Ten's, parking, amusement, financial, transportation, and hotel land use. It should be emphasized that several of these broad classes, such as automotive or parking, are not characteristic of the CBD, and their lower position within the district does not reflect a lower position within the retail structure of the city as a whole. In fact, finding automotive or parking land use within the CBD serves to emphasize the wide importance of these uses.

Breaking these broad classes of commercial establishments down into the individual types of stores, we find that the most common type of business in the Little Rock CBD is that of selling prepared food. Restaurants of all sorts make

up nearly 9 per cent of all businesses. Other important businesses are personal-service establishments such as barber and beauty shops (7.8 per cent), women's clothing stores (5.8 per cent), jewelry stores (4.3 per cent), parking (4.0 per cent), cleaning, pressing and tailoring and shoe repairing (3.7 per cent), men's clothing (3.7 per cent), household appliance sales (3.5 per cent), sporting goods and hobby stores (3.5 per cent), and bars (3.5 per cent). Oddly enough, some of the enterprises that are commonly thought of as numerous in the CBD do not prove to be so. In this class would be banks, hotels, department stores, and book stores. They may well be considered as characteristic of the CBD because they are found almost exclusively there, but even in the center these types are not numerous.

In summarizing the business types found in the Little Rock CBD, it should be emphasized that the range of these types is normal for a city of the size class. Only ten business types comprise more than 3 per cent of the establishments, but these ten uses make up nearly half of all the businesses (47.6 per cent). On the other end of the scale there are 49 different types of commerce that make up the other half. Thus, Little Rock demonstrates strikingly the nature of CBDs, that of wide variety and choice in business establishments rather than a great number of all but a few types. This small, individual representation is understandable when we realize that any city of 100,000 does not need a great number of hotels, newspapers, banks, or department stores, but it would not be much of a trade center if it did not have at least one of each of these types.

#### THE SIZE OF BUSINESS ESTABLISHMENTS IN THE LITTLE ROCK CBD

Although it would be desirable to evaluate land uses and individual establishments on the basis of their sales or rent, such data are seldom available. A possible, albeit rough, alternative is that of size of the establishment in area rather than in sales. It is obvious that the space given over to an enterprise is a measure of its economic stature. In Little Rock it has been possible to compute the mean size of all units of land use, and by comparing the various uses to this mean some ranking of individual importance is obtained.

The mean size for the land-use units in Little Rock's CBD is 6,400 square feet. This figure is as high as it is mainly because some land-use units are very large. The use with the greatest mean is that of hotels, which average 12.7 times the overall mean. Other uses that average well above the mean are department stores (6.8 times), fraternal organizations (3.9 times), public utility offices (3.3 times), banks (2.4 times), and furniture stores (2.3). In general, most governmental, organizational, and theatrical units are above the mean. On the other end of the scale, most of the miscellaneous retail types, food types, clothing types, and service trades are below the mean.

The retail types which characterize the heart of the district tend to be the larger representatives of their class. The smaller retail establishments are more generally located toward the margin of the district. Office buildings, as distinguished from individual offices, form large units within the CBD averaging 3.3 times the mean for all uses.

It is rather interesting to find that the uses which epitomize urbanism -- hotels, department stores, banks, furniture stores, and office buildings -- do bulk large in the CBD. Only clothing establishments, among business types important in our minds for large cities, falls below the mean. The many types of commerce that fill out the picture so as to make the trade center important to diverse customers tend to be small in size.

#### THE DIFFERENCES IN LOCATION WITHIN THE CBD OF THE BUSINESS TYPES

For the geographer, the physical structure of the CBD, the siting of the various land uses within the district, and the dynamic aspects of the urban morphology that are found in the CBD, hold more interest than the inventory of classes of commerce outlined above. The physical structure of the CBD is most basically one of annular gradation outward from a point. This point is that place within the CBD where the greatest degree of centrality or focus is to be found. Without going into the allied fields of land economics or merchandising, it should be apparent that commerce depends upon the greatest possible access to customers, and this access is different in the several parts of the central area.

Thus, the structure of the CBD tends to develop in accordance with two principles of land economics, a differential exists in the need for centrality among the various business types, and a differential also characterizes these businesses with regard to their ability to purchase centrality.

Some businesses such as cigar stores, drug stores, or other "impulse-sales" stores cannot survive without extreme centrality, and thus the cost of a peak-point site is figured in the overhead. Other stores such as department stores, movie theatres, or large clothing stores may desire high centrality but cannot obtain the amount of space required within a practicable overhead at the very peak point of centrality. Still other stores such as furniture stores, stores requiring customer parking, or automotive sales establishments require so much space that they must settle economically for the marginal location. In summary it may be said that the price system of centrality operates to create the annular structure of the CBD around the peak point of focus. This peak point is generally characterized by the highest volume of pedestrian flow rather than vehicular flow, for the obvious reason that motorists must become pedestrians to become shoppers.

In Little Rock the peak point of focus for pedestrians is found at the intersection of Main Street and Capitol Avenue. By constructing concentric bands based on walking distance along radiating and parallel streets, it is possible to analyze the annular structure of the city's CBD. Figure 3 shows such bands based on a unit of 100 yards' walking distance outward from the peak point. Inventorying the central-business types within these successive bands, we obtain a picture of change in use, or horizontal zonation.

The innermost band, that is, an area generally 200 yards across, centered at the peak point, is characterized by two uses -- the sale of clothing and the sale of drugs. Women's clothing stores make up the largest group, followed by general clothing stores and clothing specialty stores.

The second band, that between 100 and 200 yards from the intersection of Capitol and Main, is dominated by what we class as variety stores. Here the largest single use is in department stores, reflecting the need of these stores for centrality but their inability to secure sufficient space within the first band. Five-and-Ten-Cent stores, shoe stores, appliance-sales establishments, and office-supply sales are other uses that are found to have their greatest concentration in this zone.

The third zone in Little Rock, between 200 and 300 yards from the peak point, corresponds rather well to the general pattern in American cities by serving as the financial district. Here the banks, office buildings, brokers, and personal-service establishments show their greatest concentration. This financial zone also has a pattern that is characteristic of our cities -- it is the site of the largest number of men's clothing stores. It seems that the tie between financial-office uses and men's clothing is one of symbiosis. The only other significant use of this zone is that of furniture stores, which is an atypical use and probably results from the tendency of furniture stores in Little Rock to locate in a separate retail center away from the CBD. Thus the few stores in the CBD do not establish a true pattern.

The final zone for which it is possible to inventory land use within the CBD, that from 300 to 400 yards from the peak point, is by far the largest because of the fact that these are concentric and thus increasingly larger zones. Here the most striking feature is the concentration of food uses. Restaurants, bars, liquor stores, and super-markets have their greatest concentration within the CBD. The development of bars within this zone ties in with several other uses that concentrate here, pawn shops, movies, jewelry stores, pool parlors, and shooting galleries, to make of this peripheral zone the transient and lowest-grade shopping area. The low-grade character is further emphasized by the clustering here of "army and navy stores." This fourth zone of Little Rock follows the typical pattern by serving as the site of the greatest concentration of hotels and automotive uses. Lower land value is emphasized by the concentration in the fourth zone of the parking lots that are within the CBD.

Analysis of the concentric zones in Little Rock brings out rather well the horizontal zonation of land uses representing the final result of the price system of centrality. It should be emphasized that in general the peak point of a

city tends to shift over the years. Little Rock shows the shift that characterizes ports or river towns, a shift away from the water and at a right angle to it. The local CBD had an earlier center farther north on Main Street, first at the intersection of Markham, and then progressively farther south until the present peak point at Fifth was reached. It is common to find that the wake of the center is taken over by low-grade commerce and establishments catering to transients. Such is the case here, with two of the three bus stations, most of the pawn shops, and the associated food and amusement establishments. In a similar manner, the advance line of the highest-value part of the district tends to develop into uses that require prestige but cannot pay for high centrality. Specialty shops, office buildings, and professional offices take up the vanguard. In Little Rock, where the pull on the peak point is generally south and west, these vanguard uses are found predominantly in these two directions.

A second aspect of the structure of the central area is that of vertical zonation. This differentiation with height is a peculiar characteristic of the CBD -- no other retail area shows this "altitudinal zonation" to any marked degree. The vertical change in use can be studied in Little Rock by considering the successive layers, the individual floors. In broad outline, the space within the CBD is predominantly ground floor with 45.4 per cent (23,800,000 cubic feet) so located. The second story accounts for nearly one-quarter (24.0 per cent, 12,600,000 cubic feet) and all upper stories supply the remaining three-tenths (30.4 per cent, 16,000,000 cubic feet) of this space within the CBD.

On a closer look at the space division according to height, it appears that the uses which characterize the ground floor are many, but consist predominantly of retailing, with some admixture of service trades. Once above the ground floor, however, the number of uses drops sharply (41 as opposed to 75 on the ground floor), a reduction that is even more marked in the upper stories (27 uses). In addition, the predominance in use changes from retailing to vacancy, residence, offices, and fraternal organizations. Thirteen uses, only one of which (department stores), is retail, make up 60 per cent of the space. Of these 13 the significant uses, in order of rank, are: vacant space (10.4 per cent); offices (9.0 per cent); department stores (8.6 per cent); hotels (6.4 per cent); rooming houses (6.0 per cent); and fraternal uses (5.3 per cent); or a total of 45.7 per cent of the space. The upper stories display still less variety in use with hotels (25.6 per cent) and offices (25.1 per cent) comprising half the use. Other significant uses of upper story space are department stores (12.6 per cent), vacant space (8.3 per cent), fraternal organizations (3.3 per cent), and rooming houses (2.4 per cent) or a total for these six uses of 77.3 per cent.

In summary, it can be shown in Little Rock that there is a marked change with height. The first floor is the *domaine par excellence* of retailing, but the upper stories are either a continuation of ground floor uses, as in the case of department stores or hotels; or else are offices, rooming housing, organizations, and vacant space.

The presence of vacancy above the street deserves some attention. Our studies have shown that there are three types of vacancy -- upper-story vacancy, peripheral vacancy, and core vacancy. It is our belief that these types serve as a rough index to the health of the CBD. The most serious type in relation to this health is core vacancy on the ground floor. Little Rock has little of this. However, the innermost zone does show the greatest amount of vacancy (36.7 per cent of the total vacancy and 11.5 per cent of the zone space) caused largely by the poor use of upper stories. Again the outermost zone shows a considerable amount of vacancy (33.2 per cent of the total vacancy and 6.8 per cent of the zone space). Thus, it seems that Little Rock's CBD is not as healthy as it might be, being characterized by upper-story vacancy, the least serious sort, and peripheral vacancy, the intermediate stage. The combination of these two types of vacancy indicates that the little Rock CBD suffers either from decay of past use or competition from outside business areas. The combination of these two probably is the case.

A comparison of the horizontal and vertical zonation in Little Rock presents both similarities and contrasts. The cost of space seems to account for the fact that certain uses, personal service, offices, fraternal, and residence, seek either upper story sites in the heart of the district or ground floor sites at the edge. Contrary to common thought, another similarity is that of unit size.

The units become progressively smaller with movement outward from the center or upward at the center. The largest units are those on the ground floor at or very near the peak point. Still another similarity is the entrance of greater amounts of non-retail use with this movement outward or upward. Thus, in many ways it may be said that the CBD is rather like a geologist's laccolith, its gradation of uses takes place both horizontally and vertically.

The contrasts between horizontal and vertical zonation show up most strongly in the matter of retailing. Those enterprises that cannot support the site charges for high centrality tend to move outward but not upward. It appears that the cause for this may lie in the fact that retail stores wish to be obvious to the passers-by even if there are fewer of them than there might be at the center. Offices, on the other hand, appear to need centrality more than obtrusiveness, so they are located in upper stories close to the center. It should be pointed out that offices in all the cities studied are concentrated not at the center itself but away from it a short distance. This may well stem from the fact that the ground floor uses associated with the office district, banks, brokers, and other financial establishments, cannot afford the extreme cost of street-level sites at peak point. Another factor that may contribute to the concentration of offices away from the center is that office buildings form the largest single buildings within the CBD, and thus a few such structures provide a major part of the office space. Their type of centrality may be thought of as existing within a single building or a few adjacent buildings rather than in the CBD as a whole.

Another sharp contrast in the vertical and horizontal zonation shows up in the matter of business types. The outer parts of the CBD have a wider variety of uses, both business and non-business, than are found at the center. The upper stories in all zones, however, show a marked decrease in the number of uses.

#### CONCLUSIONS

The application to Little Rock of a standard method of delimitation worked out in nine cities in other parts of the country has afforded an opportunity to begin the study of the retail structure of Arkansas trade centers. Much more might be done in this field that would yield interesting and valuable information. There can be no doubt, after the appraisal of Little Rock, that that city is a fully developed trade center with the structure and diversity of commerce that characterize such centers. This is to be expected, and no resident would question either Little Rock's dominance in the commerce of the State of Arkansas nor its status as a fine example of the regional trade center.

Much more might be said about Little Rock, particularly with regard to the details of the business uses at the edge of the CBD -- the spread outward from this district in both annular and radial patterns, the influence of the rigid skeleton of past development on the CBD, and the symbiosis that exists among the various functions and business types in the district. However, time is limited. I should like to conclude by suggesting that the geographers of Arkansas think along the lines of detailing the picture of the commercial structure of our state. We may be certain that Little Rock is the focal point and major element in this structure, and do we know much more about the structure itself.

How well developed are subsidiary centers such as Fort Smith, Jonesboro, Fayetteville, etc., and what part do they play in the overall pattern of trade within the state? An integral part of any such broad study of trade centers should be a study of their dependencies, trade areas. I hope in the future to suggest ways of attacking this correlative. In addition, much remains to be done in Little Rock. The CBD is only one of the city's retail areas. The others deserve consideration. Still more, we might consider what is the "shadow effect" of Little Rock on North Little Rock, Benton, Pine Bluff, or Conway.



SPATIAL ASSOCIATIONS OF THE 1948, 1952  
PRESIDENTIAL VOTE

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Certain regions of the United States have become sufficiently well defined so that they are common terms and definite areas in the minds of the general population. Such terms as "the South," "the Corn Belt," "the Wheat Belt," and others are commonly used for their respective sections of the nation. In addition to these, there is a variety of other fractional divisions based on economic, soils, rainfall, and physiographic criteria. There are some sections frequently thought of as political strongholds for one or another party for reasons of sentiment or point of view.

There has been little emphasis on delimiting political regions or correlating them with other spatially distributed characteristics. The work of Robinson and Key illustrates an attempt in this direction. As an exploration of this possible association, it is desired herein to examine aspects of the vote distribution in the 1948 and 1952 presidential elections. It was hoped that such an examination would be useful in furnishing a criterion for national regions of political interest.

The initial data employed consisted of the county-by-county vote returns. These were transferred to percentage figures and an isopleth map was plotted for each major party in the 1948 election. An examination of these maps made it clear that the Republican party vote was reflected in every county and thus was a more consistent national reflection of political interest than was the Democratic and Dixiecrat vote. Consequently, only the maps showing the percentage of votes for the Republican candidates were used. The 1952 election was mapped in a similar manner. A comparison of these maps disclosed several areas where the patterns repeated. Certain of these apparently consistent patterns were selected for additional examination. Other sections may have been used and may eventually be more consistent. However, the following were chosen:

1. The South
2. Central Valley of California
3. Southern Utah
4. The Southern Highlands
5. Coastal Maine
6. Great Plains (north)
7. Northeast Missouri

The most clearly similar isopleths for the above selections were then transferred to another map (Figure 1) where their relationships might be more carefully studied. It was thought that the comparisons could possibly be made on two bases, that of a margin or boundary zone, and that between core areas of the regions. The two emphases possible are employed as feasible on this exploratory level. Furthermore, the intensity of the political interest is reflected in different percentages for each year. The following comments treat each area in respect to the patterns seen.

The voting boundaries in southeastern United States, "The South," occur where expected and show an obvious association to other patterns. The general-type-of-farming map prepared by the Department of Agriculture shows a clear association between the cotton-farming boundary and the bounds shown by the 1952, (50%) and the 1948, (30%) voting line (see map). No other association is so clear. This correlation appears to be of special interest across Oklahoma and Arkansas, Tennessee and Georgia. Within "The South" there are sections of interest in western Tennessee and northern Alabama. The 1952, (50%) line in the Mississippi bottoms does not show in 1948, but may be hidden by the political-party splits of that year. The sometimes-termed "Florida Yankee" area is reflected in the northern and southern sections of the state.

The "Southern Highlands" area seems to have affected the voting pattern, in that the Kentucky Blue Grass section shows some association with the pattern in this part of the state. In the Carolina Mountains area, the vote pattern is

clearly modified, but the basis for these changes is not clear. The importance of certain attitudes not necessarily related to the cotton growing south appears in the discordance of the type-of-farming line and the voting margin in the Virginia-North Carolina section.

The California area evinces a repetition of the dividing lines which correspond roughly to the central valley and Los Angeles lowland. It is suggested that the specialty agriculture of these localities may be pertinent factors. Farm-type maps show no clear picture. Within the central valley there are two centers of similar pattern. One is focused on Solano County, the other on Kings and Fresno counties.

Reflected primarily in Kane County, Utah, is an area of pattern correspondence. This little section stands out more by contrast than by correspondence to adjacent areas. Mormon and highly rural settlement may be the key to this pattern.

Coastal Maine is a small section where there is a repeated pattern which also maintains consistent party sentiment. The conservative "Yankee" settlement is the apparent clue to this correspondence. This is an area with a highly rural population who have a high level of living. Farming is small-scale dairy and truck farming. Summer resort activity is important.

The area of close correspondence in Northeast Missouri is outstanding. No other similar pattern has thus far been noted. This is a slightly above-average farm area of the corn belt variety. No special crops, population groups or regions are known to be in this area.

The northern part of the Great Plains, along the eastern margin especially, has several areas where the boundaries (see map) show correlation. Along with this section we may also note the association occurring in northern Minnesota. The latter lines follow generally across the dividing zone separating what is termed the cut-over area. The parts to the northeast are less productive in agriculture.

The correlations on the Great Plains margins are erratic and none too well defined, but in locations such as eastern Nebraska and South Dakota, eastern Kansas and Oklahoma there are highly similar patterns. There are known transitions between corn and wheat occurring in these areas. Cotton is involved on the Oklahoma sections. John Weaver is considering the changing corn-belt-agriculture map patterns which are related in the Dakota-Nebraska portion. H. H. McCarty, in considering various measures of regional boundaries through the same section, finds a zone of change which bears resemblance to the political preference lines.

The foregoing, along with such smaller areas as that of Ellis County, Kansas, and Wheeler, Greeley, and Howard Counties in Nebraska encourage the contention that there are discoverable associations to be found between the political voting patterns on presidential elections and other patterns in the area. Some aspects of the type of farming and zones of agricultural change may be found to be closely associated.

In retrospect, therefore, it is suggested that voting distributions show persistent patterns which can be associated with patterns of economic and type-of-farming regions, and may well be used as an indicator for other correlations. Added investigation is thought warranted.

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THE CIENTIFICOS AND THE COLLAPSE OF THE DIAZ REGIME  
A STUDY IN THE ORIGINS OF MEXICAN REVOLUTIONARY SENTIMENT  
1903-1910

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The problem of social change has long fascinated students of society. Historians, sociologists, political scientists, and philosophers have directed their efforts toward a better understanding of this intriguing phenomenon. The results of this labor have been varied. Some, and the names of Spengler, Sorokin, and Arnold Toynbee come immediately to mind, have approached the problem in the grand manner and produced broadly philosophical interpretations of the dynamics of social change and of the life histories of civilizations and cultures.<sup>1</sup> Others, in somewhat more modest fashion, have confined their attention to revolutions as a single aspect of social change, and have sought to expose the "anatomy" and reveal the uniformities or "pattern" discernable in violent social upheavals.<sup>2</sup>

These studies, stimulating in their own right for the panoramic breadth of vision which they impart, are doubly valuable if they provide insights, concepts, or tools of analysis which can profitably be applied to the study of a single revolution, in a particular country, within a strictly limited period of time. This paper is concerned with the application of Arnold J. Toynbee's concepts of Creative and Dominant Minorities to the role of the *Cientificos* in the genesis of the Mexican Revolution of 1910 which destroyed the thirty-four year regime of President Porfirio Diaz.

To be sure, the Mexican Republic, taken alone, does not constitute a civilization in any sense comparable to Toynbee's use of the term. Nor is it certain that Western Christian Civilization, of which Mexico is a part, is in that process of disintegration with which the ascendancy of Dominant Minorities is associated.<sup>3</sup> However, if attention is shifted from the macrocosm of civilization and focused on the microcosm of this particular revolutionary movement, one is impressed by a series of striking and perhaps useful parallels.

Dominant Minorities, according to the hypothesis proposed in *A Study of History*, are characterized by a lack of creative energy and original thinking, qualities which are the hallmark of a Creative Minority's contribution to a growing civilization. Instead, Dominant Minorities tend to degenerate to a static, defensive posture of social and mental fixity, in which an attempt is made to retain by force a position of inherited privilege which they have ceased to merit on the basis of creative accomplishment.<sup>4</sup> This attempt to dominate a situation in which it no longer commands the initiative causes the recalcitrant minority to become a rigid, closed corporation refusing to hand over to other aspirants a share in the oligarchy's jealously guarded privileges. Assuming the role of predatory plutocrats, they become a bureaucracy obsessed with traditionalism and past accomplishments, and affecting a detached, superior aloofness which alienates them from the rest of society and further decreases their ability to adjust to the realities of changing conditions.<sup>5</sup>

<sup>1</sup> See Oswald Spengler, *The Decline of the West* (2 vols.; New York, 1926-1928), Piterim Sorokin, *Social And Cultural Dynamics* (4 vols.; New York, 1941), especially Vol. III, *Fluctuation of Social Relationships, War, and Revolution*, and Arnold J. Toynbee, *A Study of History* (6 vols.; London, 1934-1939).

<sup>2</sup> See the bibliography on the study of revolution in Crane Brinton, *The Anatomy of Revolution* (New York, 1952), 297-315.

<sup>3</sup> Creative Minorities, according to Toynbee, are associated with growing civilizations while Dominant Minorities are characteristic of civilizations in the process of disintegration. Toynbee, *A Study of History*, IV, 280.

<sup>4</sup> For a discussion of Dominant Minorities see Toynbee, *op. cit.*, V. 26-40.

<sup>5</sup> *Ibid.*, 31-32, 47, 390.

The evidence suggests that the *Científicos* followed a similar evolution in their transformation from a Creative to a Dominant Minority in Mexican political life between 1892 and 1910. From the inception of the group, as the Union Liberal in 1892 up to the sixth election of Diaz in 1903, the *Científicos* had constituted a constructive minority of creative thinkers and reformers, strongly influenced by the currently popular Positivist Philosophy, and making a significant contribution to Mexican political development through their open criticism of the Diaz regime and consistent efforts to bring to Mexico the benefits of enlightened and scientific administration.<sup>6</sup> As men of exceptional ability, they were responsible for much that was accomplished during the most productive period of the Diaz regime.<sup>7</sup> Even their detractors were forced to admit that they were the intellectual aristocracy of the country, and should be credited almost exclusively with the great strides made in Mexican economic development.<sup>8</sup>

Then, about 1903, the group abdicated its position of critical opposition, abandoned its reform program, was absorbed into the administration, began to share in the spoils of the regime, and, as selfish defenders of a profitable *status quo*, assumed a role characteristic of Dominant Minorities.<sup>9</sup> Evidences of this transition are not difficult to find. While Diaz did not immediately surrender the administration into the hands of his former critics, the "anti-*Científico*" complex which had characterized his earlier administration was quietly abandoned. In December of 1902, Bernardo Reys, Minister of War and a violent opponent of the *Científicos*, was removed from his post by the President at the insistence of the *Científicos*.<sup>10</sup> A year later, in 1903, came another indication of the increasing dominance of the *Científicos* in the administration. Both in 1896 and in 1900 Diaz had turned to the National Porfirista Circle, enemies of the *Científicos*, to promote his reelection. Recalling the critical *Científico* program of 1892, he had been careful to prevent another convention of the Union Liberal. Now, however, the situation had changed to such an extent that Diaz turned to the *Científicos* to promote his sixth reelection, and a second Union Liberal Convention was permitted to convene in Mexico City in June of 1903.<sup>11</sup>

As further compensation for having made their peace with the dictator, on May 6, 1904, the *Científicos* were granted another of their long-standing demands. On that date Diaz permitted the reestablishment of the office of vice-president, a move which he had consistently opposed in the past, since vice-presidents had often been a source of intrigue against the chief executive. The election of Ramon Corral, a *Científico* ally and Minister of *Gobernación* since 1903, was a clear-cut victory for the group.<sup>12</sup>

This change in the policy of Diaz toward the *Científicos* is due in large measure to the changed attitude of the *Científicos* themselves. Abandoning their liberal, reforming impulse and their original ideal of social progress for the good of the nation, they became increasingly materialistic, and turned their talents to converting their influential position within the administration into personal financial gain.<sup>13</sup> This shift from political reform to the harmless con-

<sup>6</sup> While references to the *Científicos* as the sinister "brain trust" behind the Diaz regime are numerous, no reasonably complete account of their activities has appeared in English. See Charles C. Cumberland, *Mexican Revolution, Genesis under Madero* (Austin, Texas, 1952), 10-12, and Howard F. Cline, *The United States and Mexico* (Cambridge, 1953), 52-56, 433-434.

<sup>7</sup> Testimony of Henry Lane Wilson, United States Ambassador to Mexico. U. S. Congress, Senate, *Investigation of Mexican Affairs*. Preliminary report and hearing of the Committee on Foreign Relations, 66th. Congress, 2nd. Session, on Senate Resolution 106 (2 vols.; Washington, 1920), II, 2255; Ricardo Garcia Granados, *Historia de Mexico desde la restauración de la republica en 1867 hasta la caída de Porfirio Diaz* (Mexico, 1911), 266.

<sup>8</sup> Luis Cabrera, *Obras Políticas del Lic. Blas Urrea, recopilación de escritos publicados durante los años de 1909, 1910, 1911, y 1912* (Mexico, 1921), 3-8; Jose Lopez-Portillo y Rojas, *Elevación y caída de Porfirio Diaz* (Mexico, 1921), 263.

<sup>9</sup> F. Vasquez Gomez, *Memorias Políticas, 1903-1913* (Mexico, 1933), 11ff.

<sup>10</sup> Ramon Prida, *De la Dictadura a la Anarquía. Apuntes para la historia política de Mexico durante los últimos cuarenta y tres años* (El Paso, Texas, 1914), 96-97, 156, 165.

<sup>11</sup> Lopez, *Elevación y caída*, 248-254.

<sup>12</sup> Prida, *Dictadura a la Anarquía*, 264; Vasquez Gomez, *Memorias Políticas*. 14.

<sup>13</sup> Lopez, *Elevación y Caída*, 261.

cerns of influence peddling was more to the dictator's liking. Willing to overlook their economic opportunism, Diaz saw them now as a group whose talents could be useful to his administration without being a source of embarrassment. Their very success in these new intrigues, however, ultimately caused them to fall into the disrepute which is so universally associated with this group in the literature of the Mexican Revolution.<sup>14</sup>

Under these conditions it is not surprising to find in the final years of the Diaz administration the development of a system known as *cientificismo*. The system can hardly be described in the usual terms of a political party seeking its share of patronage and spoils. Party politics as such scarcely existed in Mexico at the turn of the century. Toynbee suggests that Dominant Minorities typically detach themselves from the rest of society and affect a detached, almost snobbish aloofness which alienates them from the public generally.<sup>15</sup> The *Científicos* reveal this same esotericism. They had little voluntary connection with the people, did not seek popular support or converts, did not represent the aspirations of the masses of the Republic, had little interest in affairs beyond their personal advancement, and, after abandoning the reform program of 1892, had no established platform of guiding principles.<sup>16</sup>

The *Científicos* became, in short, a sort of intra-governmental clique, "brain trust," or corporation directed by a small group of admittedly capable men -- a bureaucratic brotherhood held together by the cohesive power of public plunder and dedicated to the exploitation of the resources of the country, not by means of actual crime, but by official and quasi legal means. Toynbee's description of a "discreetly predatory plutocracy" as representative of Dominant Minorities seems to catch the spirit of *cientificismo* with remarkable precision.<sup>17</sup>

Many of the *Científicos* were lawyers. Their influence in government circles enabled them to arrange or "fix" matters in the national palace, legislative chambers, courts, and public offices. Laws were enacted and enforced with careful attention to the individuals involved.<sup>18</sup> Outsiders competing with the oligarchy were in a position of relative inferiority, and were unable to arrange and organize the large-scale enterprises and monopolies which were *Científico* specialties. As a result, they were in great demand by foreign companies to arrange concessions of all types. As a financial and political oligarchy, the *Científicos* recognized their vested interest in the government of President Diaz and were obsessed by the desire to preserve the existing order.<sup>19</sup>

In their efforts to maintain an advantageous *status quo* and prevent intrusion upon their preserve, the *Científicos* were obliged to become a closed clique. Their distrust of the masses and their consequent policy of exclusiveness provoked popular references to "*el carro completo*" -- the full car. There were no seats, not even standing room.<sup>20</sup> Even though the bureaucracy had grown tremendously and by 1910 included most literate Mexicans, these lesser civil servants were allowed no voice in shaping the *científico*-dominated policies of the administration.<sup>21</sup> The rising generation of educated creoles was excluded from the

<sup>14</sup> U. S. Congress (Senate), *Investigation of Mexican Affairs*, 88, 2254-2255. See also Henry Lane Wilson, *Diplomatic Episodes in Mexico, Belgium, and Chile* (New York, 1927), 199.

<sup>15</sup> Toynbee, *A Study of History*, IV, 233-234, V, 390.

<sup>16</sup> Lopez, *Elevación y Caída*, 272-273.

<sup>17</sup> Toynbee, *A Study of History*, V, 40. Representative accusations against rampant *cientificismo* can be found in E. D. Trowbridge, *Mexico, Today and Tomorrow* (New York, 1919), 98; Edward I Bell, *The Political Shame of Mexico* (New York, 1914), 22, and Lopez, *Elevación y Caída*, 273.

<sup>18</sup> Frank Tannenbaum, *Peace by Revolution, An Interpretation of Mexico* (New York, 1933), 100-101.

<sup>19</sup> Luis Cabrera (Blas Urrea), *Veinte Años Despues* (Mexico, 1937), 259; Roque Estrada, *La Revolución y Francisco I. Madero* (Guadalajara, 1912), 25.

<sup>20</sup> Trinidad Sanches Santos, *Editoriales de "El País" en 1910, 1911, y 1912*, compiled by M. L. Sanchez (Mexico, 1923), 78. Editorial of July 21, 1910, "El Enigma." See also Francisco Bulnes, *The Whole Truth About Mexico* (New York, 1916), 214.

<sup>21</sup> Carleton Beals asserts that virtually all literate middle class Mexicans were on the government payroll in some capacity or other. Carleton Beals, *Porfirio Diaz, Dictator of Mexico* (Philadelphia, 1932), 231.

truly important public posts where their more liberal views might have tempered or moderated the harsh Positivism of the Diaz regime.<sup>22</sup> This unwillingness to admit younger men and absorb fresh ideas gradually transformed the administration into an old man's government, hopelessly out of touch with the changing spirit of the times.

At the head of this gerontocracy was a dictator already past 80 years of age. Of the 8 cabinet members, 2 were past 80 and the youngest was 55. Of 20 state governors, 2 were past 80, 6 past 70, and 17 past 60. Government office was looked upon as an asylum for loyal patriarchs. These men, reelected and reappointed over a period of 30 years, "owned" their posts with the consent of Diaz and allowed no younger men to trespass. Because of the number of mummies they contained, journalists flippantly referred to the government offices as "the Pyramids of Teotihuacan."

Luis Cabrera summarized the extent of *Científico* domination by 1910 by asserting that both the Senate and Chamber of Deputies were effectively dominated, though often indirectly, by the *Científicos*.<sup>23</sup> Of 51 senators, 25 were *Científicos*. Of 230 deputies, 118 were tools of the *Científicos*. In the supreme court and other high offices the same situation prevailed. After 1900 these bodies were converted into mere subsidiaries of the central *Científico* machine. Cabrera concludes that 75 per cent of the public employees retained their position only through *Científico* influence.<sup>24</sup>

Thus, it can be seen that after 1903 the *Científicos* adopted another of the expedients characteristic of Dominant Minorities: the tendency to degenerate into a rigid, static, closed corporation seeking to retain their position by force and influence alone.<sup>25</sup> Though Mexico was changing, their philosophy of outdated Positivism and economic materialism had assumed the legendary rigidity of the unchanging laws of the Medes and Persians. Although the peripheral membership of the group did increase, the privileged inner circle of the oligarchy refused to admit other and younger aspirants to a share in the direction of Mexico's social and political development.<sup>26</sup> The resistance to change expressed in the "full car" psychology is evidence of the degeneration of a Creative Minority into a merely dominant bureaucracy inimical to continued creativity.

The efforts of a recalcitrant minority to retain its hold on the country by direct and forceful means are revealed in the *Científicos'* willing use of the strong arm of the dictator to crush outspoken opponents, and in their resort to a controlled press in an effort to prevent embarrassing criticism. Through Reyes Spindola, owner and editor of *El Imparcial*, the *Científicos* controlled the leading daily newspaper of Mexico City. As the "semi-official organ" of the *Científicos*, the paper prospered accordingly.<sup>27</sup> Numerous charges were made that *El Imparcial* received a handsome government subsidy and that, in addition, the *Científico* paper monopoly raised the price of newsprint for opposing papers.<sup>28</sup> In addition to *El Imparcial*, *El Debate*, the mouthpiece of Vice-president Ramon Corral, and *El Diario*, controlled by *Científico* Enrique Creel, were used by the group to further their interests. Editors who were too critical and outspoken were forced to lead a precarious opposition existence.

By virtue of their dominant position in the administration, the members of the oligarchy were able to exploit the routine functions of government for their personal benefit. Through the Treasury, they were able to dominate the other government departments by means of a law giving Minister of Finance Jose Limantour, a *Científico*, surveillance over their budgets.<sup>29</sup> Through the medium of the

<sup>22</sup> Cumberland, *Mexican Revolution*, 27-29; Tannenbaum, *Peace by Revolution*, 132-133.

<sup>23</sup> Cabrera, *Obras Políticas*, 87-116.

<sup>24</sup> *Ibid.*

<sup>25</sup> Toynbee, *A Study of History*, V, 26-31.

<sup>26</sup> Toynbee, *op. cit.*, V, 32-33.

<sup>27</sup> Walter F. McCaleb, "The Press in Mexico," *Hispanic American Historical Review*, III (1920), 444-445.

<sup>28</sup> Cabrera, *Obras Políticas*, 59-68; Carlo de Fornaro, *Mexico Tal Qual Es* (International Publishing Company, 1909), 119.

<sup>29</sup> Lopez, *Elevación y Caída*, 267.

*Compañía Bancaria de Obras y Bienes Raices*, government manipulators were provided with a convenient cloak for their fiscal intrigues. Through the *Bancaria*, officials were able to conceal their identity and to take government contracts or obtain government concessions without undesirable publicity.<sup>30</sup>

Of the many areas of *Científico* activity, the most significant in arousing anti-*Científico* sentiment was the matter of concessions and monopolies. In the case of foreign concessions, the complaint was that the concessions were excessively favorable and that the *Científicos* received scandalous fees for arranging them. Then too, the *Científicos* were guilty of securing for themselves monopolies of all kinds in violation of Article 28 of the Constitution prohibiting exclusive monopolies. Special protective legislation was enacted to cover their particular products and to guarantee exorbitant profits to the favored few.<sup>31</sup> In legislation relating to banking, tariffs, taxation, land policy, and the nationalization of railways, the public was convinced that it could see the hand of the *Científico* manipulators. Rumor and scandal were widespread in spite of the fact that many concessions were not nearly as profitable and many administration programs hardly as scandalous as was popularly believed.<sup>32</sup>

A catalog of *Científico* misdeeds could be extended to considerable length. The literature of the Revolutionary Era is filled with accusations. The figures and data are seldom dispassionate and are often unreliable.<sup>33</sup> It would be naive to assume that the *Científico* oligarchy was free of guilt. It is beyond question that various members of the group did take advantage of their favored position to grow immensely wealthy. On the other hand, the manipulations of some were popularly credited to the entire group, and *cientificismo* became synonymous in the public mind with the manipulation of public affairs for private plunder.<sup>34</sup>

That many of these accusations were false did not serve to change the popular stereotype or still the public clamor. In every instance *Científico* motives were assumed to be of the worst. Their dealings as representatives of foreign interests led to the popular impression that they were mere tools of foreign powers, and they became the focus of a rampant anti-foreign sentiment. The armed suppression of anti-foreign demonstrations by the government was interpreted as clear evidence of a sinister relationship between the *Científicos*, the government, and foreigners.<sup>35</sup> For those who remembered, the philosophy of the original *Científicos*, that of importing a foreign brand of scientific progress through a use of foreign capital and talent, only added to the growing sentiment that the *Científicos* were responsible for making "Mexico the mother of foreigners and the stepmother of Mexicans."

The *Científicos* of the dominant period, however, were not themselves concerned with their former stature and ideals as a creative minority. Their pride, their arrogance, their contempt for all outside the oligarchy, fed a constantly growing wave of anti-*Científico* sentiment. Under the circumstances, a clash between them and the masses was inevitable. The unsavory details of the past ten years were not easily ignored nor forgotten. From all quarters came the symptoms of a growing discontent.

The Creelman Interview of 1908 had done much to arouse the smoldering resentment. Madero's *La Sucesión Presidencial en 1910* published late in 1908 made him a rallying point for the opposition. Rival political parties began to campaign openly. Books and pamphlets aimed at the oligarchy appeared in increasing numbers. In 1909 Andres Molina Enriques published his *Los Grandes Problemas*

<sup>30</sup> Bell, *Political Shame of Mexico*, 7.

<sup>31</sup> W. H. Calcott, *Liberalism in Mexico, 1857-1929* (Stanford, 1931) 140. Typical of the accusations are the statements made by Pedro Gonzalez-Blanco, *De Porfirio Diaz a Carranza* (Madrid 1916), 38.

<sup>32</sup> U. S. Congress (Senate), *Investigation of Mexican Affairs*, I, 1444.

<sup>33</sup> See Cline, *The United States and Mexico*, 433-434.

<sup>34</sup> Francisco Madero who led the revolution to overthrow Diaz and *cientificismo* admits that many of the rumors and claims are unfounded and exaggerated. Francisco I. Madero, *La Sucesión Presidencial en 1910* (Mexico, 1911), 123ff.

<sup>35</sup> *Papers Relating to the Foreign Relations of the United States, 1911* (Washington, 1918), 353-354.

*Nacionales* in which, with telling effect, he revealed the extent of *Científico* domination. The regime was able to assure its return to office in 1910 only by resorting to that characteristic device of the Dominant Minority, crude and forceful suppression of the opposition.

The campaign of 1910 should have furnished Diaz and the *Científicos* with ample warning of the approaching storm. The events of that year certainly provided ammunition for the opponents of the oligarchy. It made little difference to the people whether or not all the charges and accusations made against the minority were true or whether their complicity in all the scandals credited to them could actually be established. The significant point was that the public believed the things they heard, and it was this belief that swelled the ranks of *maderistas*. They knew that the door of opportunity was closed to them because of the "full car" policy. They could not speak, write, or publish with impunity. They could not enter politics because the events of the last campaign indicated that in reality politics still were not permitted. They could not hold offices, these were preempted by the *Científico* gerontocracy.

Thus, one of the causes of the revolt that dethroned Diaz was hatred of dominant *cientificismo*, a hatred revealed in the revolutionary battle cry, "Death to the *Científicos*." The revolution was not simply against Diaz as a tyrant, but against the *Científicos* who surrounded him.<sup>36</sup> It was a revolt against the social and mental fixity of the closed corporation, against the business monopoly of dominant *cientificismo*, against the rigid preservation of a system of special privilege, and finally, against a philosophy of government, once creative and constructive, but now purely negative and little more than an elaborate rationalization to justify the continued ascendancy of the Dominant Minority. It was, in short, the Mexican repudiation of those qualities which, according to the Toynbee thesis, are universally characteristic of Dominant Minorities.

A letter of American Ambassador Henry Lane Wilson to his government dated November 26, 1910, points up the special vengeance of the masses for the *Científicos*, even greater, perhaps, than their dislike of the dictator himself. He reports, "there is deep animosity on all hands... to the *Científico* group which surrounds the President, and in my opinion, it is only respect and fear of the President which restrains a formidable movement."<sup>37</sup>

Even as Wilson wrote of a "formidable movement," the revolution was already in progress. Francisco Madero had already issued his Plan of San Luis Potosi calling the people to arms. In spite of the President's last-minute offers of liberal reforms, the revolution spread rapidly, moved beyond control, and triumphed. On May 25, 1911, Diaz resigned the Presidency, and with his fall, *cientificismo* as the institutionalized expression of a Dominant Minority ceased to exist.

One may well conclude that the role of the *Científicos* in the long Diaz administration was an important one indeed. The picture of Pre-revolutionary Mexico can hardly be understood without constant reference to that unique group. Much of the controversy and misunderstanding surrounding the *Científicos* stems from a failure to emphasize the distinction between the group as a truly Creative Minority, and, later on, as a merely Dominant Minority.

It is in helping to point up this contrast that the Toynbee concepts seem helpful. It is granted that any extremely literal application of these concepts to the specifics of the Mexican case is out of the question.

<sup>36</sup> Jose Fernandez Rojas, *De Porfirio Diaz a Victoriano Huerta, 1910-1913* (Mexico, 1913), 129.

<sup>37</sup> *Papers Relating to the Foreign Relations of the United States, 1911, 367-368.*



AN EXCEPTIONAL DECISION  
THE TRIAL OF PROFESSOR RICHARD T. ELY BY THE BOARD OF REGENTS  
OF THE UNIVERSITY OF WISCONSIN, 1894

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In 1892 Richard T. Ely, a German-trained political economist, surrendered his chair at Johns Hopkins to become head of a new School of Economics, Political Science and History at the University of Wisconsin, one of the many state universities undergoing physical and academic expansion in the closing years of the century. At that time a national scene characterized by agrarian unrest, waves of immigration from unaccustomed sources, industrial conflict, and political disputes centering around tariffs and monetary standards afforded scholars a realm for speculation ranging from the reactionary to the visionary. Meanwhile, sensational journals and sober periodicals alike were inclined to focus public attention on faculty aberrations and accomplishments. As the incidence of theological proscription in higher education declined, a new set of clashes involving political economy and sociology were evoking bitterly contested and well publicized academic-freedom disputes.

University life in America had proven sufficiently flexible to allow for modification of curricula and the slow growth of a spirit of free inquiry, but it had not evolved sufficiently to permit facile solutions for the crises of the 1890's. Fundamentally, professors continued to be employees of private corporations or of governmental entities, potentially removable by arbitrary action of the authorities.<sup>1</sup> Instructors and administrative officers held concepts of their relative positions which often made them incapable of friendly understanding of each other's problems. A university president, writing in a popular magazine as "One of the Guild," in 1900 asserted that most professors were weaklings who held their jobs chiefly because there were not enough really good men to go around.<sup>2</sup> Opinions of some teachers and their advocates about the administrators were no more flattering. Z. S. Holbrook believed that the modern college president, motivated by a zeal for money-getting, was "a cross between a theologian and a Napoleon of finance." He singled out a particular administrator who "oscillates between a maudlin sentimentalism about Jesus and an undertone of diplomacy and intrigue that would excite the contempt of Henry VIII for its shallowness and its transparency."<sup>3</sup> In specific instances of disagreement such judgments could be even more severe.

In addition to their internal problems, academic communities were frequently hampered by perplexing external pressures. Private institutions often owed their solvency to the generosity of donors from the business world who were in a position to influence the course of research and instruction. Vigorous assertions of disinterestedness by men of wealth did not allay the fears of implied restraint which some teachers felt.<sup>4</sup> By the turn of the century bitter academic-freedom disputes had been fought out at Chicago, Brown, Cornell, and Stanford Universities.<sup>5</sup> Meanwhile, state-supported institutions of higher learning also

<sup>1</sup> E. C. Elliott and M. M. Chambers, *The Colleges and the Courts; Judicial Decisions Regarding Institutions of Higher Education in the United States* (New York, 1936), 71-75; Alexander Brody, *The American State and Higher Education, The Legal, Political and Constitutional Relationships* (Washington, 1935), 150, 152.

<sup>2</sup> "Perplexities of a College President," *Atlantic*, 85:486-487, 490-491 (April, 1900).

<sup>3</sup> Z. S. Holbrook to Richard T. Ely, November, 1895, Richard T. Ely Papers, State Historical Society of Wisconsin.

<sup>4</sup> Chicago's economist Edward Bemis, for example, charged that an eastern college's faculty considered it a matter of conscience to accept a Rockefeller gift "lest in refusing it, while accepting others no better they would injure Mr. Rockefeller's reputation." Edward Bemis to Henry Demarest Lloyd, September 10, 1895, Henry Demarest Lloyd Papers, State Historical Society of Wisconsin.

<sup>5</sup> S. R. Bolnick, *The Development of the Idea of Academic Freedom in American Higher Education, 1870-1920*, unpublished Ph.D. dissertation, University of Wisconsin, 1951.

progressed gradually toward the university ideal, but some of them suffered virtual academic civil wars in the process. As agencies of public service under legislative control, they were subject to the vicissitudes of changing political currents. In the words of a state university president's wife, "political trickery... here is always on the alert to get quacks and politicians into the faculty."<sup>6</sup> During the 1890's intermittent squabbles between the authorities of the University of North Carolina and Trinity College (later Duke University) impeded the development of both centers of learning. And during the same period Kansas State College witnessed a ludicrous series of mass hirings and firings of faculty members as the Republicans and Populists alternately controlled the state government.<sup>7</sup>

Aside from meeting the direct demands of sponsoring authorities and performing the traditional functions of teaching and inquiry, academic centers were popularly expected to provide all manner of auxiliary benefits. Theories set out in the pages of *Education* illustrate the perplexities. An editorial in 1889 deplored the excessive emphasis on the doctrine of free trade in American universities, but a writer in the same journal a few months later announced that it was a duty of all economists to call attention to the responsibility of protectionism for impoverishing the nation's agricultural population.<sup>8</sup> A few years later Charles F. Thwing, an eminent educator, maintained that the college should "cause noble character to blossom in noble doing, as noble doing is the seed of yet more noble character."<sup>9</sup> But such a goal was vague. Baylor University's President Rufus Burleson sought to make his institution a nursery of "learning, piety, and patriotism," while Professor Alexander Ormond of Princeton believed that the "higher schools and universities" should serve as "centers of self-criticism" so that society could be "purged from its evil extreme tendencies, and its energies be directed into productive channels."<sup>10</sup> Even where publicly viewed violations of academic freedom did not result, rumors and actual instances of pressures on professors to conform to certain patterns were common during the 1890's.

The career of Richard T. Ely epitomized many of the trends and problems of the academic world in a rapidly changing society. He had received his early training at Columbia and then had studied in Europe. In the mid-eighties Ely played a leading role in founding the American Economic Association and in the expression of its principles. Eventually he taught at Johns Hopkins, a major private institution, and at Wisconsin, an important state university. The unconventional nature of the economist's teaching and scholarship involved him in more than one clash with authority, and some of his activities were subjects of sharp public controversy. In a series of talks in Baltimore on the history of political economy Ely defied the approach of the older generation of classical economists. But he explained to Hopkins' President Gilman that he

should not endeavor so much to teach or enforce any specific economic doctrines as to explain the various theories actually maintained by those who have contributed in one way or another to the growth of the science.<sup>11</sup>

In 1891 a talk on "The Progress of Socialism" brought from the *Philadelphia Telegraph* the observation that the professor's private expression of his ideas was

<sup>6</sup> Josephine Raymond to Richard T. Ely, May 5, 1900, Ely Papers.

<sup>7</sup> Paul Neff Garber, *John Carlisle Kilgo: President of Trinity College, 1894-1910* (Durham, 1937), 34-56, 166-224; Aubrey Lee Brooks, *Walter Clark, Fighting Judge* (Chapel Hill, 1944), 109-121; Luther L. Gobbel, *Church-State Relationships in North Carolina Since 1776* (Durham, 1938), 132-171; Julius T. Willard, *History of Kansas State College of Agriculture and Applied Science* (Manhattan, Kansas, 1940), 96 ff.

<sup>8</sup> *Education*, 9:343 (January, 1889); Arthur Latham Perry, "Preparations for Citizenship at Williams College," *Education*, 9:518 (April, 1889).

<sup>9</sup> Charles F. Thwing, "The Relation of the College to the Community," *Education*, 11:421-422 (March, 1891).

<sup>10</sup> Alexander T. Ormond, "University Ideals at Princeton," *ibid.*, 1897, p. 357.

<sup>11</sup> Ely to Gilman, September 23, 1881, Daniel Coit Gilman Papers, Johns Hopkins University Library.

not dangerous, "but when he teaches such doctrines in the name or with the sanction of a most respected seat of learning in the United States, he becomes at once an exceedingly dangerous teacher."<sup>12</sup> The authorities did not restrain Ely, but his candid approach to social problems alarmed some factions close to the Baltimore university. In a public meeting which the Hopkins economist addressed, President John Cowen of the Baltimore and Ohio Railroad, "speaking like a Pope," vehemently attacked the professor's interpretations. When Ely subsequently responded in kind, Cowen retorted that he would never send any of his sons to Hopkins as long as Ely was there. Although President Gilman eventually heard more about the incident from the railroad official, who was also a University trustee, he never reprimanded Ely.<sup>13</sup>

When Ely moved to Wisconsin in 1892 to head the new School of Economics, Political Science and History, he joined with historian Frederick Jackson Turner and other colleagues in an effort to provide a type of advanced training in the social sciences that could prepare students to analyze the causes for social and economic problems, and so train them in research methods that they would seek independent solutions for these problems. This work led eventually to the close association between the university and the state government during the progressive period--the "Wisconsin Idea" which attracted national attention and imitation in some states. In such relatively new fields as sociology, as well as in the older social sciences, the men whom Ely brought to Madison consistently interested themselves in practical affairs as well as in basic research, and their conclusions could not be expected always to satisfy every element in the community. But before the School had completed its second full year, a violent attack was leveled at Ely, beginning with a controversy in the press and culminating in a public trial before a committee of the Wisconsin regents.<sup>14</sup>

The furor began in midsummer of 1894 when Wisconsin's Superintendent of Public Instruction, Oliver Wells, attacked the professor in the columns of the *Nation* and the *New York Evening Post*. Wells accused Ely of involvement in union activities in Madison and the perpetration of writings embodying "utopian, impractical, or pernicious doctrines." Wells charged specifically that the university economist had demanded the unionization of the strike-bound firm where he sometimes had printing work done, and had consorted with the delegate who was in charge of the strike. Ely had, moreover, allegedly informed one of the owners of the shop that

a dirty, dissipated, unmarried, unreliable, and unskilled tramp, if a union man, should be employed in preference to an industrious, skillful, trustworthy, non-union man who is the head of a family.

And "essentially the same principles" were propounded in Ely's books.<sup>15</sup>

The prevailing mood in the state and nation was highly sensitive to charges of this kind as a consequence of economic dislocation attending the panic of 1893 and the recent and violent Pullman strike in Chicago, but there was no immediate sensational reaction in the university community. President Charles Kendall Adams of the university and many of Ely's colleagues considered the attack groundless, and some friends counselled him to initiate a libel suit against Wells, and to request a regents' investigation. But there were serious doubts both as to the fairness of any trial in view of the atmosphere of excitement which might be generated and the wisdom of tacitly granting the right of university authorities to censor faculty teaching and writing. Ely himself was in Virginia, far away from the controversy, and was unable to decide on an immediate plan of counterattack in the face of much well intentioned but confusing advice.

<sup>12</sup> Ely to Herbert Baxter Adams, July 19, 1882, Herbert Baxter Adams Papers, Johns Hopkins University Library; clipping from *Philadelphia Telegraph*, February 9, 1891, in Gilman Papers.

<sup>13</sup> Richard T. Ely, *Ground Under Our Feet: An Autobiography* (New York, 1938), 102; Ely to Lloyd, December 24, 1895, Lloyd Papers.

<sup>14</sup> The work of the School is discussed in Merle Curti and Vernon Carstensen, *The University of Wisconsin, A History* (2 vols., Madison, 1949), vol. 1, 630-645. Except where otherwise noted the account of the attack on Ely and the trial is based on *ibid.*, 508-527 and the Ely Papers, June-August, 1894.

<sup>15</sup> *Nation*, 59-27 (July 12, 1894).

Before the harrassed professor could act, the Board of Regents, over the opposition of a minority, selected a committee of its members to investigate the charges against Ely.

The appointment of the committee forced the professor and his supporters to make some sort of counter move. A number of Ely's professional friends, especially his former student, David Kinley, then teaching at the University of Illinois, and Frederick Jackson Turner, provided advice and collected evidence in his behalf. Before the regents began their hearings Bishop John H. Vincent read to a summer Chautauqua audience Ely's categorical reply to the charges. It pictured Wells as a shameless politician and publicity seeker; Ely declared that he himself was not only opposed to socialism and anarchism but that he had become in the course of time "on the whole, more conservative." The reply concluded with an impressive listing of Ely's former students.

Meanwhile, news of the impending trial gave editorialists of metropolitan newspapers an opportunity to formulate their opinions on this academic imbroglio with strong political undertones. The Democratic *Baltimore Sun* and the Populist *Non-Conformist* of Indianapolis joined the *Journal of the Knights of Labor* in defending the accused teacher. Numerous papers took the middle position that Ely should be fired if he were found guilty of teaching erroneous doctrines, and the staunchly Republican *Inter-Ocean* of Chicago openly denounced the practice of anarchists and socialists holding university posts.<sup>16</sup> The Madison newspapers generally were friendly toward Ely in the early stages of the dispute.

The regents' committee began to wrestle with the tangled issues of the case early in August. The group's composition did not suggest any sharp political bias. Dr. H. B. Dale, a physician, and John Johnson, Milwaukee banker and something of a scholar, were Democrats. Regent H. W. Chynoweth was a Republican generally believed to be conservative, but he was also a long-time associate of Wisconsin progressive leader Robert LaFollette. One of the most important questions which these men faced was whether to look into Ely's writings, for the answer would indicate the extent of freedom of research for scholars at the university. It soon became evident that they would limit their inquiry to Ely's recent classroom teaching. Superintendent Wells was not present for the opening public hearing on August 20, but he sent a long letter reiterating his conviction that the economist's work was damaging to the state university, and demanding that Ely's writings as well as his teachings be scrutinized. Wells and his attorney did attend the second meeting the following evening, and despite their forceful representations concerning admission of Ely's books as evidence, the committee denied the request. Regent Chynoweth flippantly inquired whether the plaintiff wished to inflict on the committee "a reading of these entire works"; with more cogency Regent Johnson pointed out that there was no necessary connection between Ely's teaching and his writing and that the implications of censorship in such a course were highly disturbing. "It would put this committee in a very unenviable position," he concluded, "to sit as censors upon all such books."

With the scope of the investigation temporarily settled, the regents took up the specific charge against Ely, and the unfolding of the actual trial was anticlimactic. Witnesses from the printing firm gave evidence that the professor had not threatened a boycott but had merely urged them to recognize the union for fear that the Christian Social Union, of which he was secretary, might not permit its work to be done by an anti-union plant. The allegation that Ely had connived with a walking delegate named J. F. Klunk turned out to have been based on an understandable but comical error. Superintendent Wells' informants had mistaken H. H. Powers, one of Ely's students who had actually met with Klunk, for the economist himself because both wore short, full beards. After the committee had adjourned again, Wells reaffirmed his opposition to the circumscribed range of the inquiry, and sent another letter to the committee. This he buttressed with quotations from Ely's *Socialism and Reform*, but he held that it was difficult to cite implicating passages from a work "so innocent of clear cut thought, and so uniformly barren of explicit statements."

Toward the end of the trial, during the meeting of August 23 from which Wells and his lawyer were again absent, the regents agreed to receive evidence about Ely's books. These data consisted of letters from scholars and journalists

<sup>16</sup> "Professor Ely Charged with Heresy," *Public Opinion*, 17:462 (August 16, 1894).

which pointed up the basic conservatism of the Wisconsin economist on most social issues of the day. With these testimonies the defense has thoroughly discredited the general attack on Ely's "utopian, impractical, or pernicious doctrines."

There remained little doubt that the board would acquit Ely, but the inquiry had begun to harm the university, and the widespread publicity tended to multiply this effect. A writer in the *Dial* late in the summer observed:

It has been reserved for the University of Wisconsin to offer the first example, to our knowledge, of a trial for heresy in which theology has no part. To hale a public teacher of science before an investigating committee, for the purpose of examining his opinions and pronouncements upon their orthodoxy from a purely scientific viewpoint, is a procedure so novel, and...so startling, that one may well pause to consider its significance, and the possible consequences of an extension of the principle thus involved.<sup>17</sup>

A simple exoneration of the accused would have shown that he could not legitimately be called an enemy of the existing social order but that would have done little toward affirming academic freedom. The state and nation witnessed intense controversy in the 1890's, and questions of the rights of laborers, farmers, and businessmen were by no means agreed upon. If it had been shown merely that a professor of economics was not opposed to the rights of private property, the fundamental concept of the university as an arena for the free flow of ideas would hardly have been demonstrated. At the suggestion of John M. Olin, a professor in the law school, the regents' committee prepared a report which not only cleared Ely but also set forth its formal position on freedom for teachers. The regents emphasized the numerous publications of the faculty and their "diversity of views regarding the great questions which at present agitate the human mind," and the impossibility of maintaining a great university if professors were to be dismissed or criticized for opinions regarded as visionary in some quarters. The report concluded with an apostrophe to academic freedom:

We cannot for a moment believe that knowledge has reached its final goal, or that the present condition of society is perfect... In all lines of academic investigation it is of the utmost importance that the investigator should be absolutely free to follow the indications of truth wherever they may lead. Whatever may be the limitations which trammel inquiry elsewhere we believe that the great state University of Wisconsin should ever encourage that continual and fearless sifting and winnowing by which alone the truth can be found.

The board as a whole adopted the committee report and passed a resolution censuring the superintendent who had initiated the charges. The university profited from a widespread acceptance of the report and the noble sentiment favoring free inquiry buttressed the idea of academic freedom. Despite occasional periods of turmoil in the subsequent history of the University of Wisconsin, the declaration was never officially repudiated.<sup>18</sup>

The Ely trial provided an opportunity for people outside the university community to become better acquainted with the kind of work which went on there, and to appreciate the anomalies in the status of professors. An observer in the *Dial* proposed an improvement by which the beginner would have probationary standing and the man who had "won his professional spurs" would enjoy tenure. The democratic tenet that the "voice of the people is the voice of God," urged the writer "is a challenge to a society which has to deal with some matters that can be judged only by the trained intellect."<sup>19</sup> A respondent quickly reaffirmed the traditional attitude with the dour observation that teachers were part of "the great army of the employed" and should be accountable to some higher authority lest they should advocate wild and untried theories.<sup>20</sup>

<sup>17</sup> "Freedom of Teaching," *Dial*, 17:103 (September 1, 1894).

<sup>18</sup> When the Wisconsin Class of 1910 voted to present to the University a plaque bearing the last sentence of the regent statement, the regents accused the class of being influenced by radicals and of joining with them in attacking regent policies. Five years later the plaque was accepted and placed at the entrance of the main university building.

<sup>19</sup> "Freedom of Teaching," *Dial*, 17:103-104 (September 1, 1894).

<sup>20</sup> Duane Mowry, "Freedom of Teaching," *Dial*, 17:149 (September 16, 1894), letter to the editor.

Within educational circles, the Wisconsin experience provided valuable lessons for other heretics, but the disturbing implications of the trial lingered. As late as 1901 Ely complained that "I have not, myself, entirely gotten over the effects of the unjust attacks upon me six years ago."<sup>21</sup> Just before the Ely trial the administration at one other institution adopted an attitude of increasing caution rather than greater tolerance toward potential radicalism. Early in June of 1894 the trustees of Johns Hopkins University decided that the important current "political, economic, financial and social questions" should be discussed before students "only by the ablest and wisest persons whose services the university can command." They asked the executive committee to make a special report on the subject, and recommended in the interim that "great caution in the selection and engagement of lecturers and other teachers" be exercised.<sup>22</sup> Possibly this precautionary measure enabled that university to avoid some of the difficulties faced by other institutions in a period of social and economic ferment. But the next half century was to bring to the academic world recurrent crises, shaped by continuing disagreements among men as to the limits of the pursuit of truth and by the occasional impact of sharpened emotions accompanying wartime emergencies.

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<sup>21</sup> Ely to E. A. Ross, March 19, 1901, Ely Papers.

<sup>22</sup> Gilman sent a copy of the report to Herbert Baxter Adams; June 5, 1894, Gilman Papers.

ON ESTIMATES OF ERROR IN NUMERICAL INTEGRATION

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INTRODUCTION

In order to determine numerical approximations for definite integrals, the principal methods used are the trapezoidal rule and Simpson's rule. In this paper, upper bounds are established for the errors obtained by these two methods. The error resulting from use of the trapezoidal rule is expressed in terms of the second derivative of the integrand, and that incurred in Simpson's rule is expressed in terms of the fourth derivative. A difference formula, analogous to Taylor's formula with remainder, is established. This relation is then used to derive expressions for the errors in terms of second and fourth differences respectively.

ERROR IN TERMS OF DERIVATIVES

The procedure is based on the Fundamental Theorem of the integral calculus. Let a subdivision of the interval from  $x = a$  to  $x = b$  into  $n$  parts be given by the points  $a = x_0, x_1, \dots, x_n = b$ , with  $x_{i+1} - x_i = 2\delta$ . The midpoint of the subinterval from  $x_i$  to  $x_{i+1}$  is designated by  $\bar{x}_i$ . From the formula  $f(x) = f(\bar{x}_i) + (x - \bar{x}_i)f'(\bar{x}_i) + \frac{(x - \bar{x}_i)^2}{2!}f''(\xi)$  with  $\xi$  between  $x$  and  $\bar{x}_i$ , it follows that

$$\int_{x_i}^{x_{i+1}} f(x)dx = [f(\bar{x}_i)] 2\delta + E_1, \text{ with } E_1 \leq \frac{\delta^3}{3} \text{Max } |f''(x)|.$$

For one subdivision, the approximate area,  $A$ , as defined by the trapezoidal rule is

$$A = \frac{1}{2} [f(x_i) + f(x_{i+1})] 2\delta. \tag{1.1}$$

Hence  $A$  is given by this rule as

$$A = [f(\bar{x}_i)] 2\delta + E_2, \text{ where } E_2 \leq \delta^3 \text{Max } |f''(x)|. \tag{1.2}$$

From (1.1) and (1.2) it follows that, in one subdivision, the actual error of the trapezoidal rule satisfies the inequality

$$E \leq E_1 + E_2 = \frac{4}{3} \delta^3 \text{Max } |f''(x)|. \tag{1.3}$$

But  $2\delta = w$ , the width of one subdivision, so that  $\delta = \frac{w}{2}$ . Hence

$$E \leq \frac{1}{6} w^3 \text{Max } |f''(x)|. \tag{1.4}$$

Then, for  $n$  subdivisions, the total error obtained in the trapezoidal rule is

$$E_t \leq \frac{n w^3 \text{Max } |f''(x)|}{6}, \tag{1.5}$$

and since  $nw = b - a$

$$E_t \leq \frac{(b - a) w^2 \text{Max } |f''(x)|}{6} \tag{1.6}$$

The error resulting from Simpson's Rule can be lumped into an expression containing the fourth derivative. Developing the expansion of  $f(x)$  for two more terms, the result is

$$f(x) = f(\bar{x}_i) + (x - \bar{x}_i)f'(\bar{x}_i) + \frac{(x - \bar{x}_i)^2}{2!}f''(\bar{x}_i) + \frac{(x - \bar{x}_i)^3}{3!}f'''(\bar{x}_i) + \frac{(x - \bar{x}_i)^4}{4!}f^{(4)}(\bar{x})$$

with  $\bar{x}$  between  $x$  and  $\bar{x}_i$ .

For the two subdivisions from  $x_{i-1}$  to  $x_i$  and from  $x_i$  to  $x_{i+1}$ , we have

$$\int_{x_{i-1}}^{x_{i+1}} f(x) dx = [f(\bar{x}_i)] 4\delta + \frac{8\delta^3 f'''(\bar{x}_i)}{3} + E_3, \quad (2.1)$$

$$\text{where } E_3 \leq \frac{8\delta^5}{15} \text{Max } |f^{(5)}(x)|.$$

In these two subdivisions,  $A$ , as defined by Simpson's rule is

$$\begin{aligned} A &= \frac{2\delta}{3} [f(x_{i-1}) + 4f(x_i) + f(x_{i+1})] \\ &= \frac{2\delta}{3} [f(\bar{x}_i - 2\delta) + 4f(\bar{x}_i) + f(\bar{x}_i + 2\delta)], \text{ and since} \end{aligned}$$

$$\begin{aligned} [f(\bar{x}_i - 2\delta) + 4f(\bar{x}_i) + f(\bar{x}_i + 2\delta)] &= 6f(\bar{x}_i) + \frac{8\delta^2}{2!} f''(\bar{x}_i) + \frac{16\delta^4}{4!} [f^{(4)}(\bar{x}_i + \theta_1 2\delta) + f^{(4)}(\bar{x}_i - \theta_2 2\delta)] \\ &0 < \theta_1 < 1, \quad 0 < \theta_2 < 1, \end{aligned}$$

the value for  $A$  is

$$A = 4\delta [f(\bar{x}_i)] + \frac{8}{3} \delta^3 f'''(\bar{x}_i) + E_4 \quad (2.2)$$

$$\text{with } E_4 \leq \frac{8}{9} \delta^5 \text{Max } |f^{(5)}(x)|.$$

From (2.1) and (2.2) it follows that an upper bound for the actual error in Simpson's rule for the two subdivisions is given by

$$E \leq E_3 + E_4 = \frac{64}{45} \delta^5 \text{Max } |f^{(5)}(x)|. \quad (2.3)$$

$$\text{Hence, when expressed in terms of } w, E \leq \frac{2}{45} w^5 \text{Max } |f^{(5)}(x)|. \quad (2.4)$$

For the entire interval, the error in Simpson's rule is then bounded as follows:

$$\begin{aligned} E_S &\leq \frac{2}{45} w^5 \text{Max } |f^{(5)}(x)| \frac{n}{2}, \text{ and, as } nw = b-a, \\ E_S &\leq \frac{(b-a) w^4 \text{Max } |f^{(5)}(x)|}{45} \end{aligned} \quad (2.5)$$

Thus  $E_t$  and  $E_s$  give upper bounds in terms of derivatives for the trapezoidal rule and Simpson's rule respectively.

#### DIFFERENCE INTERPOLATION FORMULA WITH REMAINDER

When it is difficult to obtain the derivatives of the integrand, Taylor's Formula with remainder may be replaced by a difference interpolation formula with remainder. An expression for the remainder after one term (Mean Value Theorem for differences) for the difference interpolation formula will be established. Likewise, an expression for the remainder after two terms will be determined.

**THEOREM.** If the function  $f(x)$  is continuous in the interval  $a \leq x \leq a+p\delta$ , then with each value of  $x$  in that interval there is associated a value  $\eta$  satisfying  $|\eta| \leq |p|$  such that

$$f(a+p\delta) = f(a) + p \Delta f(a) + \frac{p(p-1)}{2!} \Delta^2 f(a) + \dots + \frac{p(p-1) \dots (p-n+1)}{n!} \Delta^n f(a+\eta\delta).$$

**PROOF.** The following equations are valid:

$$\begin{aligned} f(a+p\delta) - f(a) &= \sum_{n=1}^p \{f[a+n\delta] - f[a+(n-1)\delta]\} \\ &= \sum_{n=1}^p \{\Delta f[a+(n-1)\delta]\}. \end{aligned}$$



The continuity of  $f(x)$  implies the continuity of  $\Delta f(x)$ . Therefore, the last summation over  $p$  terms may be replaced by the expression  $p\Delta f(\bar{x})$ , with  $a \leq \bar{x} \leq a+p\delta$ .

This relationship can also be expressed as

$$f(a+p\delta) = f(a) + p [f(\bar{x}+\delta) - f(\bar{x})],$$

which is designated as the Mean Value Theorem for differences.

**COROLLARY.** If  $f(a+p\delta) = f(a) = 0$ , then  $f(\bar{x}+\delta) = f(\bar{x})$ , where  $\bar{x}$  is some intermediary  $x$ .

Consider now the quantity  $K$  defined by the equation

$$f(a+p\delta) = f(a) + p\Delta f(a) + \frac{p(p-1)}{2!} K.$$

If  $a + p\delta = b$ , the equation takes the form

$$f(b) - f(a) - \frac{b-a}{\delta} \Delta f(a) - \left(\frac{b-a}{\delta}\right) \left(\frac{\frac{b-a}{\delta} - 1}{2!}\right) K = 0$$

Define  $F(x)$  as follows:

$$F(x) = f(b) - f(x) - \left(\frac{b-x}{\delta}\right) \Delta f(x) - \left(\frac{b-x}{\delta}\right) \frac{\left(\frac{b-x}{\delta} - 1\right)}{2!} K.$$

Then  $F(a)$  and  $F(b)$  are both zero. But by the above corollary there exists a value  $\bar{x}$  between  $A$  and  $B$  for which  $\Delta F(\bar{x})$  vanishes.

When  $F(x)$  is evaluated at  $(x+\delta)$  and the difference  $F(\bar{x}+\delta) - F(\bar{x})$  determined and simplified, the result is

$$\Delta F(\bar{x}) = \Delta^2 f(\bar{x}) \left[1 - \frac{b-\bar{x}}{\delta}\right] - \left[1 - \frac{b-\bar{x}}{\delta}\right] K = 0.$$

Solving for  $K$  we obtain

$$K = \Delta^2 f(\bar{x}), \text{ with } a \leq \bar{x} \leq b = a+p\delta.$$

The general result for a remainder after  $n$  terms can be established by analogous reasoning.

#### ERRORS IN TERMS OF DIFFERENCES

The difference interpolation formula with remainder in the second difference is

$$f(\bar{x}_1 + \xi\delta) = f(\bar{x}_1) + \xi\Delta f(\bar{x}_1) + \frac{\xi(\xi-1)}{2!} \Delta^2 f(\bar{x}_1 + \eta\delta), \quad 0 \leq \eta \leq \xi. \quad (3.1)$$

Let  $x = (\bar{x}_1 + \xi\delta)$ . Then

$$\int_{\bar{x}_1 - \delta}^{\bar{x}_1 + \delta} f(x) dx = \int_{-1}^1 f(\bar{x}_1 + \xi\delta) \delta d\xi = 2\delta f(\bar{x}_1) + E_1', \text{ with } E_1' \leq \frac{\delta}{3} \text{Max} |\Delta^2 f| \quad (3.2)$$

For the trapezoidal rule

$$A = \frac{1}{2} [f(x_i) + f(x_{i+1})] 2\delta \text{ takes the form}$$

$$A = \frac{1}{2} [f(\bar{x}_1) - \Delta_1 + f(\bar{x}_1 + \Delta_2)] 2\delta, \text{ where } \Delta_1 = \Delta f(x_i) = \Delta f(\bar{x}_1 - \delta) \quad (3.3)$$

$$\text{and } \Delta_2 = \Delta f(\bar{x}_1)$$

Simplifying, we obtain

$$A = 2\delta f(\bar{x}_1) + E_2' \text{ with } E_2' \leq \delta \text{Max} |\Delta^2 f|. \quad (3.4)$$

Thus the error in one subdivision in terms of differences for the trapezoidal rule can be expressed by the inequality

$$E_1' \leq E_1' + E_2' \leq \frac{4}{3} \delta \text{Max} |\Delta^2 f| = \frac{2}{3} w \text{Max} |\Delta^2 f|. \quad (3.5)$$

For  $n$  subdivisions, the resulting total error in the trapezoidal rule is then

$$E_t' \leq \frac{2}{3}nw \text{Max}|\Delta^2F|, \text{ so that}$$

$$E_t' \leq \frac{2}{3}(b-a) \text{Max}|\Delta^2F|. \quad (3.6)$$

For Simpson's Rule the error can be expressed in terms of a fourth difference. When the difference interpolation formula with remainder is developed through two more terms, the result is

$$f(\bar{x}_1 + \xi\delta) = f(\bar{x}_1) + \xi\delta f'(\bar{x}_1) + \frac{\xi(\xi-1)}{2!} \Delta^2 f(\bar{x}_1) + \frac{\xi(\xi-1)(\xi-2)}{3!} \Delta^3 f(\bar{x}_1) +$$

$$+ \frac{\xi(\xi-1)(\xi-2)(\xi-3)}{4!} \Delta^4 f(\bar{x}_1 + \eta\delta) \text{ where } 0 \leq \eta \leq \xi. \quad (4.1)$$

Therefore

$$\int_{\bar{x}_1 - 2\delta}^{\bar{x}_1 + 2\delta} f(x) dx = \int_{-2}^2 f(\bar{x}_1 + \xi\delta) \delta d\xi = 4\delta f(\bar{x}_1) + \frac{8}{3}\delta \Delta^2 f(\bar{x}_1) - \frac{8}{3}\delta \Delta^3 f(\bar{x}_1) + E_3' \quad (4.2)$$

$$\text{where } E_3' \leq \frac{134\delta}{45} \text{Max} |\Delta^4 f|.$$

For Simpson's Rule

$$A = \frac{2}{3}\delta [f(\bar{x}_1 - 2\delta) + 4f(\bar{x}_1) + f(\bar{x}_1 + 2\delta)] \text{ becomes}$$

$$A = \frac{2}{3}\delta \{ [f(\bar{x}_1) - \Delta_1 - \Delta_2] + 4f(\bar{x}_1) + [f(\bar{x}_1) + \Delta_3 + \Delta_4] \}, \quad (4.3)$$

$$\text{where } \Delta_n = f[\bar{x}_1 + (n-2)\delta] - f[\bar{x}_1 + (n-3)\delta], \quad n = 1, 2, 3, 4.$$

Since

$$\Delta_4 = \Delta_3 + \Delta_3^2$$

$$\Delta_2 = \Delta_3 - \Delta_3^2 + \Delta_3^3 - \Delta_3^4$$

$$\Delta_1 = \Delta_3 - 2\Delta_3^2 + 3\Delta_3^3 - 3\Delta_3^4 - \Delta_1^4$$

$$A = 4\delta f(\bar{x}_1) + \frac{8}{3}\delta \Delta_3^2 - \frac{8}{3}\delta \Delta_3^3 + E_4' \quad (4.4)$$

$$\text{where } E_4' \leq \frac{10}{3}\delta \text{Max} |\Delta^4 f|.$$

Then, for the two subdivisions, the upper bound for the error in Simpson's Rule satisfies the following relations:

$$E' \leq E_3' + E_4' \text{ or}$$

$$E' \leq \frac{284}{45} \delta \text{Max} |\Delta^4 f| = \frac{142}{45} w \text{Max} |\Delta^4 f|. \quad (4.5)$$

We obtain finally, for the entire range  $a \leq x \leq b$

$$E_s' \leq \frac{142}{45} \left(\frac{n}{2}\right) w \text{Max} |\Delta^4 f| \text{ or}$$

$$E_s' \leq \frac{71}{45} (b-a) \text{Max} |\Delta^4 f|. \quad (4.6)$$

These two results for  $E_t'$  (3.6) and  $E_s'$  (4.6) establish, in terms of differences, upper bounds for the errors in the trapezoidal rule and Simpson's rule respectively.

## THE PROBLEM OF COMMON FUNGUS INFECTION

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Superficial fungus infections of the skin constitute one of the most common of all diseases. This is particularly true in the South where the higher mean temperature promotes their growth. The superficial fungus infections about which I will speak today require keratin for growth. It is because of this that they involve only the skin and its appendages and do not invade deeper organs and structures. Keratin is the main constituent of the outermost layer of the skin and is the substance of which nail and hair are composed. The superficial fungus infections are not considered consequential by the clinician and the researcher as they are not crippling or killing diseases. Nevertheless, the chronic fungus infection with its periodic acute flareups is, for the patient afflicted, indeed a serious disorder, not only from the standpoint of his suffering, but also because it may constitute an economic burden as a result of the time lost from work and the expense of the treatment. During World War II fungus infections were one of the more common causes, if not the most common, of non-battlefield casualties. Because there is such widespread involvement of the population with superficial fungus infections, the loss to the country as a whole undoubtedly amounts to many millions of dollars every year.

Bacterial infections have fallen in face of the onslaught of the numerous antibiotics, but no such broad approach is yet available in the superficial fungus infections -- with one exception, this being the fungistatic effect on certain fungi of the fatty-acid preparations. Although time honored, remedies containing sulfur, salicylic acid, benzoic acid, aniline dyes, or ammoniated mercury are nevertheless of limited usefulness. It, therefore, seems appropriate that more attention be directed to everyday fungus infections, and today I should like to discuss this problem with you, including the relationship of therapy to the growth characteristics of the organisms on the human skin.

**MALASSEZIA FURFUR:** This organism is the etiologic agent for a disorder known as *tinea versicolor*. It lives in the keratin layer of the skin and usually causes no symptoms but constitutes only a cosmetic problem. It cannot be cultured on ordinary media, and because of this it has been impossible to study its metabolism and to develop more effective therapeutic agents. Microscopic examination of preparations of scales removed from lesions readily reveals short, curved, hyphae and grape-like clusters of spores. This constitutes the characteristic and diagnostic picture of this disease. Although this infection is widely prevalent, it is not particularly contagious even among members of the same family. It would appear that part of the population is susceptible to this infection, while the remainder are completely immune. The disease is commonly active during the summer months, recurring year after year and involving principally the trunk and the proximal portions of the extremities. In areas unexposed to the sun the lesions are fawn-colored, slightly scaling, rounded patches, while in areas exposed to the sun the lesions are depigmented in sharp contrast to the normally tanned skin. The fact that the organism prevents tanning in areas exposed to the sun has, to my knowledge, never been studied. It has never been determined whether this lack of tanning is a result of the organism or its products acting as a physical screening agent such as *paraminobenzoic acid*, or whether this effect is due to a biochemical inhibition of pigmentation. Treatment consists of the use of elementary sulfur in varying vehicles, and although the response is usually good, the disease is very prone to recur.

**CANDIDA ALBICANS:** This organism grows very rapidly on Sabouraud's media, and produces a disease known as *moniliasis* or thrush. Growth on corn meal agar media is an acceptable means of distinguishing it from other species of *Candida*. *Candida albicans* may be a normal inhabitant of the lower gastro-intestinal tract, and is therefore readily available to produce cutaneous disease in the susceptible patient by contamination of the skin surface. Monilial involvement of the vaginal vault is a common disorder, and, under proper circumstances, external cutaneous involvement may take place. Diabetes, for instance, predisposes to such cutaneous involvement because of the increased sugar in this area as a re-

sult of urinary contamination. Thrush, a common monilial infection of the mucous membranes of infants is another example of the growth of the organism as a result of the host's inability to resist. In markedly debilitated patients, generalized cutaneous involvement may be seen. At times the use of the bacterial antibiotics enhance the growth of monilia in the gastro-intestinal tract previously inhibited by the bacterial flora. Overgrowth of *Candida albicans* in the gastro-intestinal tract of course increases the likelihood of cutaneous involvement. Moniliasis of the paronychial areas of the fingers in women who have their hands in water frequently is common. Eventually the organism invades the nails, and this may result in considerable disfigurement of the nails.

Treatment in any of the above conditions is far from ideal. It usually involves an attempt to improve the host's physical state -- for example, the administration of insulin to control the glucose level in a diabetic and the administration of a topical remedy. A standard remedy is the purple dye, gentian violet. This is frequently effective if the patient's general status is good. Occasionally the fatty-acid preparations are helpful.

Rarely moniliasis may result in granulomatous lesions of the skin similar to the disease produced by the deep fungi such as blastomycosis. This granulomatous condition is unresponsive to all therapy and is in time fatal.

**TRICHOPHYTON RUBRUM:** This organism, easily cultured on Sabouraud's media, produces a fluffy white surface growth with a characteristic dark red pigment on the reverse. Cutaneous involvement may result in a most recalcitrant and resistant type of disease. Many patients, when first seen by a physician, have already had their disease for years. An individual lesion may arise in an area no larger than a few millimeters in diameter, but in time, with peripheral extension, the lesion may reach a diameter of a foot or more. This gradual increase in the size of a lesion may take place in the face of the best available treatment. *Trichophyton rubrum* is also quite prone to involve the fingernails and toenails, producing a gradual degeneration and destruction of the nails. One of the most striking features of *Trichophyton rubrum* infections is the common occurrence of involvement of the skin of one palm, producing a scaling, hypertrophic, diffuse type of lesion. This lesion may exist on one palm for many years without involvement of the opposite palm. Here it is evident that local susceptibility is an important factor, for obviously there is ample opportunity for the infection to spread to the normal palm. This is a most interesting phenomenon and should point to some clue as to the nutritional requirements of the organism. Although this disease may exist continuously for many years in one form or another in a patient, there are only two reports in the entire medical literature in which the infection spread from the patient to other members of the same household, thus indicating that there is also a marked variation in susceptibility between individuals as well as between local areas in the same individual. One recent report demonstrated that these people have an increased tolerance to glucose; i. e., a flattened curve on intravenous administration of a test dose of glucose. This is one of the first available clues to possibly explain the variations in individual susceptibility. Skin involvement with *Trichophyton rubrum* shows striking seasonal variation in Arkansas. Here the lesions become active in April, gradually enlarging until November when, with cooler weather, they subside almost completely. In the North, because the period of warm weather is shorter, the involvement is never as extreme and the lesions never as large. Extensive *Trichophyton rubrum* infections are actually very rare in the North. In contrast, in southern Florida the lesions persist and continually enlarge the year round without seasonal fluctuation. Thus, all the advances of modern medicine must bow to Mother Nature, for cool weather is by far the most effective treatment, topical remedies being of limited value.

The nail involvement also is just as unresponsive to treatment. Fungus infections of the nails as a whole are quite difficult to treat, *Trichophyton rubrum* being the most obstinate. Experienced dermatologists have remarked many times that they have never seen a *Trichophyton rubrum* infection of the nail cured.

**TRICHOPHYTON MENTAGROPHYTES:** This is the most common of the superficial fungi and can be easily cultured on Sabouraud's media. In Arkansas it is the usual etiologic agent in athlete's foot (*Tinea pedis*), crotch itch (*Tinea cruris*), and other forms of ringworm. Frequently this type of infection is overtreated with one or several proprietary preparations, producing more irritation than the

disease itself. If an effective treatment is used, it is very often used only until the patient is free of symptoms, and not necessarily free of the infection. Therefore, recurrence at a later date is the rule. This infection responds well to therapy with the fatty acid preparations. Treatment, to be effective, must usually be persisted in for from four to six weeks even though all visible signs of the disease may have disappeared during the first two weeks of therapy.

*Microsporum Audouini*: Beginning about 1940 the United States came to grips with a virulent pandemic of ringworm of the scalp. Originally the northern and eastern states, particularly the metropolitan areas, were confronted with thousands of cases in children. In time the pandemic involved the Middle West, and by 1947 approximately 4,000 cases were estimated to be present in St. Louis, Missouri. Gradually the epidemics waned in those areas but were not there contained, for the infection now has spread to the South. Recently in several localities in Arkansas large numbers of cases have been reported, and it is quite likely that the infection now smoldering in other areas of the state will soon demonstrate heightened activity.

The etiologic organism of this pandemic of ringworm of the scalp is *Microsporum audouini*. This organism is easily cultured on Sabouraud's media, producing a characteristic growth. When invasion of hair takes place, the disease eventually so weakens the hair that it is easily broken, and if a number of hairs are involved, patches of partial alopecia appear. Examination of an area of involvement under a filtered ultraviolet light reveals a striking green fluorescence in contrast to the non-fluorescence of non-infected hair. The nature of this phenomenon has been studied, but it is not at all clearly understood. *Microsporum audouini*, in addition to causing ringworm of the scalp, may also invade the non-hairy skin and the nails. The scalp disease is primarily an infection of children and adolescents below age fifteen. The organisms form a sheath of spores and hyphae around the hair and gradually grow down the hair shaft and into the root. As new hair is formed at the root and grows out, the infection spreads to the new hair so that there is continuous involvement of the entire hair shaft including the root, although new hair is being formed all the time. Unless proper therapy is instituted, the disease may last from months to years. However, during puberty, infection undergoes spontaneous healing. It has been demonstrated that this is due to a fungistatic effect of changes in the sebum occurring at puberty. Topical therapy for tinea capitis has never been very effective. Although fungistatic agents locally applied kill the fungus exposed on the surface of the hair, they will not penetrate to the infection in the root of the hair shaft. Therefore, effective therapy has always involved removal of infected hair from the patient.

COMMENT: From what has been said, it should be apparent that fungus infections constitute an ever-present problem, particularly in Arkansas and in the South. It will be solved only by continued research both at basic and clinical levels, directed on the one hand to determining the growth habits and requirements of the fungi, and on the other hand to the pathologic physiology of the host that accounts for the differences in susceptibility between individuals and between different areas of the same individuals.

In considering the possible solutions to the problem, two are worthy of mention. Certainly an effective antibiotic or other chemo-therapeutic agent for topical application in a limited disease, or for systemic administration when involvement is widespread, would be of considerable value, particularly in *Trichophyton rubrum* infections. It is doubtful that a systemically administered fungistatic agent would be effective in nail disease as the agent would not actually reach the disorder. Nail disease might well be cured by a physical agent such as intense cold.

It has not been my purpose to appear pessimistic or assume a defeatist attitude, but rather to present the problem of the superficial fungus infection in its true light in the hope that new awareness of its magnitude and importance might be aroused.

PATIENTS IN ARKANSAS' STATE MENTAL HOSPITAL  
FROM TWO ARKANSAS COUNTIES<sup>1</sup>

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As part of a larger investigation of the outcome of hospitalization for mental illness, a group of 146 patients in the Arkansas State Hospital were investigated with regard to their background characteristics, recovery levels, and hospital adjustment. All patients studied were admitted to the State Hospital from Washington and Jefferson counties in the period 1930-1948.<sup>2</sup> Washington County, in the northwest corner of the state, is partly in the Ozarks, partly in a plains area. Jefferson County is in the Mississippi delta. The populations of both counties are more than fifty per cent rural, though Washington County has one city of close to 20,000, and Jefferson County has one city close to 40,000 population. Admission rates from each of the counties were close to the state average.

This paper is concerned with the patients who were in the State Hospital at the time released patients were investigated in their homes and communities. Field investigations were completed during 1949 in Washington County and during 1950 in Jefferson County.<sup>3</sup> Eighty-five (17 per cent) of the 502 persons admitted from Washington County and 61 (11 per cent) of the 552 patients admitted from Jefferson County were in the State Hospital at the time of the investigation.<sup>4</sup> The proportion of hospitalized patients in the latter group was smaller because more persons from Jefferson County had died in the hospital. This higher mortality was due to the timing of the investigation which caused deaths during an additional six months to be included, and to the higher proportion of Negro patients from Jefferson County.

Information about the backgrounds of the patients was obtained from the hospital files. Information about their recovery level and hospital adjustment was obtained by interview with the physicians in whose charge they were.

Among the 146 hospital patients from both counties, 47 had never left the hospital. Of these, 47 per cent had been in the hospital five years or less; 15 per cent had been there from five to ten years; and 38 per cent had been hospitalized ten years or more. Among all patients who had been released, 95 per cent had been hospitalized five years or less during first admission; four per cent had been there from five to ten years; and only one per cent had been hospitalized ten years or more.

At the time of the follow-up study, 99 patients were in the hospital as a result of readmissions. These patients were not in the hospital during their first admissions appreciably longer than other living patients in the sample, but they had an average total length of stay in the hospital of more than eight years as compared to less than 16 months for all patients.

<sup>1</sup> This study was sponsored jointly by the Arkansas State Board of Health, the Arkansas State Hospital, and the University of Arkansas Institute of Science and Technology, the latter agency actually carrying out the investigation. A part of the funds supporting the study were provided by the above named agencies and a part by a research grant, M-499, from the National Institute of Mental Health of the National Institutes of Health, Public Health Service.

<sup>2</sup> A Monograph summarizing the Washington County Study has been published: Leta M. Adler, James W. Coddington, and Donald D. Stewart, *Mental Illness in Washington County, Arkansas: Incidence, Recovery, and Post Hospital Adjustment*. (Little Rock and Fayetteville: Arkansas State Hospital, Arkansas State Board of Health, and University of Arkansas Institute of Science and Technology, 1952).

<sup>3</sup> No patients admitted for the first time had been in the hospital less than one year from Washington County or 18 months from Jefferson County. The sample is, therefore, not representative of all patients in the State Hospital at a given time.

<sup>4</sup> During 1930-1948, 543 Washington County patients were admitted, but a random sample of 41 was drawn for pretesting schedules and methods. The 552 Jefferson County patients were a fifty per cent random sample of all admissions during the years in question.

Thus, the group of patients hospitalized at the time of the follow-up study represented a relatively permanent hospital population and accounted for a greatly disproportionate amount of the total time spent in the hospital by Washington and Jefferson County patients. On the basis of an investigation of hospital deaths, it is to be expected that a large proportion of these patients will die in the hospital.

There was a disproportionate number of women among the hospitalized patients, 20 per cent of them as compared to 10 per cent of the men admitted being in the State Hospital at the time of the investigations. This difference is partially accounted for by the larger proportion of men who died in the hospital, but even more by the men who died after release. From both counties, the proportion of persons diagnosed as mentally deficient and schizophrenic was greater among patients still hospitalized than among total admissions. A disproportionately large number of the hospitalized group were under 30 years of age at the time of the study, principally because of fewer hospital deaths, not fewer releases, among the younger patients. The proportion of admissions who were still hospitalized at the time of the field work did not differ significantly for whites and Negroes among the Jefferson County patients.

The sample of patients in the hospital at the time of the investigation represented the entire range of seriousness of mental illness from one patient rated as completely recovered by his psychiatrist to some incapable of the most elementary self-care. These patients were rated with regard to their mental condition and their hospital adjustment on the basis of two scales. The theory on which these scales are based is, briefly, that patients who scored well on the item on which the fewest patients scored well, should also have scored well on all other items. For example in the case of the Mental Condition Scale, those patients who had socially acceptable and realistic plans for their futures were also described by the psychiatrist as ready for at least a trial visit home, and scored similarly high on other items. Each scale type represents a shift from a favorable rating to an unfavorable rating on one scale item, the least favorable scale type including an unfavorable rating on every scale item.<sup>5</sup> Scales were constructed separately for Washington and Jefferson County patients, but upon comparison they were found to be the same.

The proportions of patients classified in each of the 11 scale types of the Mental Condition Scale (Table 1) were roughly equal except in the case of the two non-scale types (types in which the progression of the scale was broken) in which there were fewer persons. About one in five patients was ready for a trial visit home. While all of these persons did not have plans for the future, all had some insight into their illness, their intellectual processes were more or less undisturbed, and they had only slight or occasional disturbance of emotion or behavior.

At the other end of the Mental Condition Scale were one in three of the hospitalized patients whose intellectual processes were completely distorted and one in ten who, in addition, exhibited severe and continuous distortion of emotion and behavior. Scale scores indicate that the mental condition of hospitalized men was superior to that of women.

The Hospital Adjustment Scale (Table 2) ranked the patients according to the privileges granted them, their ability to get along with other patients, their ability to carry out tasks, and their ability to care for themselves. It was found that patients who had the privilege of free access to the hospital grounds, 13 per cent of the total, also scored high on the other items, (Scale Type 1) and another 13 per cent scored equally well except that their access to the hospital premises was limited to some degree (Scale Type 2). At the opposite end of the scale were patients who did not get along well with other patients, had no assigned tasks, and needed help with at least one aspect of their personal care. These constituted 20 per cent of the total. (Scale Scores 8, 9, 10).

Patients who had been released from the hospital one or several times before the study had higher Hospital Adjustment scores than the patients who had never been released, although their recovery-level scores were not significantly bet-

<sup>5</sup> The method of constructing the scales employed in this paper is described in a mimeographed reprint of "The Cornell Technique of Scale and Intensity Analysis," a paper presented by Louis Guttman to the Conference on Measurement of Consumer Interest which was held at the University of Pennsylvania in May, 1946.

ter. Scale scores indicated that both the mental condition and the hospital adjustment of men was superior to that of women.

Table 1

MENTAL CONDITION OF 85 WASHINGTON COUNTY PATIENTS AND 58 CLASSIFIABLE JEFFERSON COUNTY PATIENTS IN THE STATE HOSPITAL CLASSIFIED BY SCALE TYPES AND SCALE SCORES, 1949 AND 1950, RESPECTIVELY

Scale score	Description of Scale Type	Patients	
		Number	Percentage
1	Patient had acceptable plans for future; rated by psychiatrist as recovered at least sufficiently for trial visit home; deep or superficial insight; no memory disturbance or only for recent or for past events, not both; oriented with regard to time, place, and person; no more than partial reasoning defect; not continuously and markedly depressed, hyperactive, or destructive.	14	10
2	Had unacceptable or no plans for future; otherwise like Type 1.	16	11
3	Had unacceptable or no plans for future; not sufficiently improved for trial visit or unimproved; otherwise like Type 1.	17	12
4 (Non-scale)	Had unacceptable or no plans for future; not sufficiently improved for trial visit or unimproved; not oriented with regard to time; otherwise like Type 1.	5	3
5	Had unacceptable or no plans for future; not sufficiently improved for trial visit or unimproved; no insight; otherwise like Type 1.	16	11
6 (Non-scale)	Had unacceptable or no plans for future; not sufficiently improved for trial visit or unimproved; superficial insight; disturbance of memory for both recent and past events; otherwise like Type 1.	4	3
7	Had unacceptable or no plans for future; not sufficiently improved for trial visit or unimproved; no insight; disturbance of memory for both recent and past events; not oriented with respect to time; otherwise like Type 1.	13	9
8	Had unacceptable or no plans for future; not sufficiently improved for trial visit or unimproved; no insight; disturbance of memory for both recent and past events; not oriented with respect to time and place; otherwise like Type 1.	15	11
9	Had unacceptable or no plans for future; not sufficiently recovered for trial visit home, unimproved or regressed; no insight; disturbance of memory for both recent and past events; not oriented with respect to time, place, and person; otherwise like Type 1.	9	6.
10	Had unacceptable or no plans for future; not sufficiently recovered for trial visit home, unimproved or regressed; no insight; disturbance of memory for both recent and past events; not oriented with respect to time, place, and person; reasoning defect complete; otherwise like Type 1.	19	13
11	Had unacceptable or no plans for future; not sufficiently recovered for trial visit home; unimproved or regressed; no insight; disturbance of	15	11

(Continued)



memory for both recent and past events; not oriented with respect to time, place, and person, reasoning defect complete; markedly and continuously depressed and/or hyperactive and/or destructive.

Total: 143 100

Table 2

1	Patient had full ground privileges; socialized well at scheduled recreational events, supervision of assigned tasks never or only sometimes required; socialized well with other patients at least sometimes; able to feed, dress, and keep himself clean without aid.	19	13
2	Had partial or no ground privileges; otherwise like Type 1.	19	13
3	Had partial or no ground privileges; never or only sometimes socialized well at scheduled recreational events; otherwise like Type 1.	26	18
4	Had partial or no ground privileges, never or only sometimes socialized well at scheduled recreational events; could not perform tasks without supervision; otherwise like Type 1.	10	7
5	Had partial or no ground privileges; socialized well at scheduled recreational events; had no assigned tasks; otherwise like Type 1.	11	8
6	Had partial or no ground privileges; never or only sometimes socialized well at scheduled recreational events; had no assigned tasks, otherwise like Type 1.	14	10
7	Had partial or no ground privileges; never or only sometimes socialized well at scheduled recreational events; had no assigned tasks; did not socialize well with other patients; otherwise like Type 1.	16	11
8	Had partial or no ground privileges; never or only sometimes socialized well at scheduled recreational events; had no assigned tasks; did not socialize well with other patients; required help with personal cleanliness or was chronic soiler; otherwise like Type 1.	10	7
9	Had partial or no ground privileges; never or only sometimes socialized well at scheduled recreational events; had no assigned tasks; did not socialize well with other patients; required help with personal cleanliness or was chronic soiler; needed help or reminders to dress or refused to wear clothes; otherwise like Type 1.	7	5
10	Had partial or no ground privileges; never or only sometimes socialized well at scheduled recreational events; had no assigned tasks; did not socialize well with other patients; required help with personal cleanliness or was chronic soiler; needed help or reminder to dress or refused to wear clothes; had to be reminded to eat or was spoon-fed or tube-fed.	11	8
Total		143	100

## SUMMARY AND CONCLUSIONS

1. Patients hospitalized at the time of the follow-up study were not representative of total admissions with respect to sex, age, diagnosis, or amount of time spent in the hospital.

2. One-fifth of the patients were sufficiently recovered for a trial visit home. Most of these were retained in the hospital because their families were unable or unwilling to accept them, or offered unsuitable surroundings for the patient. Since the hospital had no facilities for extending its service outside its walls, it was rarely able to place patients with families other than relatives. Some patients remained simply for lack of transportation home. If patients able to leave the hospital could be accommodated outside, it would help to alleviate the over-crowded hospital conditions.

3. Patients who had been released from the hospital one or more times had better hospital adjustments than patients who had never been released, although the mental-condition scores of the two groups did not differ significantly. This appears to indicate that occasional release from the hospital and return to the community is conducive to the maintenance of social skills.

4. The scales measuring mental condition and hospital adjustment were constructed independently for the two counties but were found to be identical. The homogeneity of the hospital environment and the special character of mental illness were evidently more effective than the considerable cultural differences of the two counties in determining the nature of the scales.

The fact that two different samples of patients from two different counties studied during two different years yielded the same scales speaks well for the reliability of the scales, at least for Arkansas State Hospital patients. A partial test of validity was obtained by including in each scale an item which indicated a rating of the patient by hospital personnel; in the mental condition scale, a recovery rating by the patient's physician; in the hospital adjustment scale, an item concerning ground privileges. The rank ordering of patients with regard to these was compatible with the rank ordering of the total scales.

5. It is possible that the two scales presented here, or a modification thereof, might prove useful and convenient means of classifying mental hospital patients, and provide a standard for measuring their improvement.

MALE SEX BEHAVIOR AT A SOUTHERN UNIVERSITY

L. R. FLOERCHINGER

University of Arkansas

Sixty-six males were selected for this survey. They were selected among persons known to the investigator in roughly proportional relationship to the total male population of a small southern university (henceforth referred to as X University), with regard to religion and academic class. The subjects were approached individually. The importance of the survey was explained to them; they were given an anonymous questionnaire and an envelope addressed to the author. Of the 66 questionnaires distributed, 56 were returned.

The survey indicated that 42 (75%) of the 56 subjects had experienced sexual intercourse. This proportion is higher than that found by Kinsey in a comparable group.<sup>1</sup>

Table 1

Age of student at time of first intercourse		
	Age	Number of Males
Under	15	6
	15-16	17
	17-18	13
	19-20	5
	21-22	1
Total		42

Over 71 per cent of the non-virgins had their first intercourse between the ages of 15 and 18. These would be the years when a boy is in high school or the first year of college. Only one of the 42 non-virgins first had intercourse over the age of 20.

The age of the girl with whom the boy first had intercourse is shown in Table 2.

Table 2

Age of girl with whom student had first intercourse		
	Age of Girl	Number of Males
Under	15	7
	15-16	15
	17-18	9
	19-20	4
	21-22	4
Over	22	3
Total		42

The age of the girls seem to be a little older than that of the boys. (See Table 1) This can be explained by the fact that some boys' first intercourse occurred with prostitutes, who were in every case older than the boys.

The subjects were asked to compare their socio-economic class with that of the girl with whom they first had intercourse. (See Table 3) Only three of the subjects listed the girl with whom they first had intercourse as being from a higher socio-economic group. It is quite evident that there was exploitation of lower socio-economic class girls. This phenomenon observed by many sociologists has again been verified. It is understandable that some of the subjects did not know the socio-economic class from which the girl came, when we take into consideration that the first intercourse of some subjects was with prostitutes. The author believed that, had these girls' socio-economic background been known,

<sup>1</sup> Kinsey, Pomeroy, and Martin, *Sexual Behavior in the Human Male* (Philadelphia and London: W.B. Saunders Company, 1948), p. 400.

the percentage of lower class girls would have been even higher. The subjects' social relationship with the girl at the time of the first intercourse was investigated, and all categories in Table 4 were about equally represented.

Table 3

Socio-economic Class of the boy in comparison with the socio-economic class of the girl with whom he first had intercourse

<u>Socio-economic Class</u>	<u>Number of males</u>
Boy's father higher	24
Girl's father higher	3
Same	7
Don't know	8
Total	42

Table 4

Boy's social relationship with the girl at the time of first intercourse.

<u>Social Relationship</u>	<u>Number of males</u>
Going steady	8
Dating quite often	6
Dating occasionally	6
First date	5
Prostitute	8
Pick-up	8
No answer	1
Total	42

The subjects were asked if they had had intercourse more than once with this first girl. Eighteen (43 per cent) answered yes. Twenty-four (57 per cent) answered no. Not one of the boys who first had intercourse with a prostitute, had intercourse with her again. Only 25 per cent of the boys who first had intercourse with a pick-up had relations with her more than once.

The males were asked whether they thought the girl was a virgin. The majority of the boys (74 per cent) had their first intercourse with girls reported to have had previous sexual experiences. The author questions whether the boy took the entire initiative in these situations.

The question was asked whether methods were used to prevent pregnancy at the time of the boy's first intercourse. Twenty-five (60 per cent) answered yes and seventeen (40 per cent) answered no. However, many of the boys whose first intercourse was with a prostitute answered no. The author believes that they may have failed to realize it if the prostitute was taking means to prevent pregnancy. The boys who first had intercourse with girls they were dating and took no means to prevent pregnancy were usually of age sixteen or under. Perhaps at this age they had no knowledge of how to prevent pregnancy.

The questionnaire asked whether the girl was under the influence of alcohol at the time of the boy's first intercourse. Only one boy answered "yes" to this question. This seems to expose as a fallacy that mainly girls who are drinking will agree to have premarital intercourse.

The subjects were asked about the number of different girls with whom they had had intercourse. Seven of every eight boys had had intercourse with more than one girl. Four boys had had intercourse with more than ten girls. (See Table 5)

Over 78 per cent of the boys had had intercourse six or more times, with the largest single group having had intercourse more than ten times. This seems to be an indication that once a boy has had intercourse, he will continue to have it. (See Table 6)

Table 5

Number of different girls with whom subject had had intercourse

<u>Number of different girls</u>	<u>Number of males</u>
One	5
Two	4
Three	7
Four	10
Five	2
Six to ten	9
Over ten	4
No answer	1
<b>Total</b>	<b>42</b>

Table 6

Number of times subject had had intercourse

<u>Number of occurrences</u>	<u>Number of males</u>
One	3
Two	3
Three	1
Four	1
Five	2
Six to ten	11
Over ten	20
No answer	1
<b>Total</b>	<b>42</b>

Some comparisons were made between the other characteristics of virgins and non-virgins but these findings must be considered as merely suggestive because of the size of the sample and the method by which it was selected.

Table 7

Religious preference as related to sexual experience

<u>Virginal Status</u>	<u>Protestant</u>	<u>Catholic</u>	<u>None</u>	<u>Total</u>
Virgin	10	4	0	14
Non-virgin	39	1	2	42
<b>Total</b>	<b>49</b>	<b>5</b>	<b>2</b>	<b>56</b>

Over 79 per cent of the Protestant males had had intercourse, while only one of the five Catholic subjects was a non-virgin. However, the Catholic sample is too small to draw adequate conclusions. (Table 8) No individual of the Jewish faith was included in the survey because they constitute but one-half of one per cent of the total male population enrolled at X University.

Contrary to the findings of other sociological studies, the socio-economic class of the subject shows little relation to sex behavior. The reason for this apparent lack of relationship may well be that nearly all the students are of the middle or upper socio-economic classes. It may be noted in Table 8, however, that all the subjects whose father was a professional worker, semi-professional worker, farmer, or farm manager had had sexual intercourse.

Table 8  
Socio-economic class as related to sexual experience

<u>Occupation</u>	<u>Virgin</u>	<u>Non-virgin</u>	<u>Total</u>
Professional and Semi-professional workers	0	7	7
Farmers and farm managers	0	8	8
Proprietors, managers and officials	7	22	29
Clerical, sales, and kindred workers	6	3	9
Operatives and kindred workers	0	1	1
Craftsmen, foremen, and kindred workers	1	1	2
Total	14	42	56

Comparison of the subjects' home communities as to size was more revealing. (Table 9) Almost 43 per cent of the non-virgins were from areas under 1,000 population or from cities of over 50,000 population, while only one virgin was from these same population areas. This can possibly be explained by the fact that in towns under 1,000 population and in rural areas, there are few facilities for commercial recreation. It is interesting to note that all boys except one from this population area had their first intercourse with a girl with whom they were dating rather than with a pick-up or a prostitute. In comparison, the most boys from city areas over 50,000 in population had their first intercourse with pick-ups or with prostitutes.

Table 9  
Size of home community as related to sexual experience

<u>Community size</u>	<u>Virgin</u>	<u>Non-virgin</u>	<u>Total</u>
Farm	0	4	4
Town population under 1,000	0	3	3
Town population 1,000-2,500	1	3	4
City population 2,500-10,000	7	10	17
City population 10,000-50,000	5	11	16
City population 50,000-100,000	1	9	10
City population over 100,000	0	2	2
Total	14	42	56

The subjects were asked their opinion of the happiness of their parents' marriage. (Table 10) The four boys who classified their parents as being unhappily married or very unhappily married had all had intercourse. A home in which disharmony is present seems to be a factor influencing the son's sexual life. Also, only one of the subjects from such a home preferred to marry a virgin. The others were completely indifferent.

The survey investigated whether or not having a sister influenced the boys' sexual experience. Fifty-seven per cent of the virgins had sisters: 52 per cent of the non-virgins had sisters also. No relationship appears to exist here. This is contrary to the popular belief that many boys feel that since they have a sister and since they wouldn't want her to be sexually abused, they wouldn't engage in premarital sexual relations either. (Table 11)

There appears to exist a relationship between the age of the boy and his sexual experiences. (Table 12) Of the virgins in the survey, 57 per cent were 18

years of age or younger, while only 21 per cent of the non-virgins were 18 years of age or younger. This implies that many of the younger boys of the sample will have sexual intercourse during the next few years.

Table 10

Opinion of parents' marriage as related to students' sexual experience

<u>Student's opinion</u>	<u>Virgin</u>	<u>Non-virgin</u>	<u>Total</u>
Very happily married	5	19	24
Happily married	6	13	19
Average	3	6	9
Unhappily married	0	1	1
Very unhappily married	0	3	3
Total	14	42	56

Table 11

Female siblings as related to student's sexual experience

<u>Sexual experience</u>	<u>Sister or sisters</u>	<u>No sister</u>	<u>Total</u>
Virgin	8	6	14
Non-virgin	22	20	42
Total	30	26	56

Table 12

Age as related to sexual experience

<u>Years of age</u>	<u>Virgin</u>	<u>Non-virgin</u>	<u>Total</u>
17 - 18	8	9	17
19 - 20	4	23	27
21 - 22	2	7	9
23 - 24	0	3	3
Total	14	42	56

Table 13

College classification as related to sexual experience

<u>Class</u>	<u>Virgin</u>	<u>Non-virgin</u>	<u>Total</u>
Freshman	8	10	18
Sophomore	3	12	15
Junior	1	16	17
Senior	2	4	6
Total	14	42	56

Since the boys' college classification is highly correlated with his age, we find about the same result as above. (Table 13)

The survey studied the virgins' and the non-virgins' attitude toward marrying a virgin. (Table 14) Quite a distinction was found here. Fifty-seven per cent of the virgins definitely wanted to marry a virgin. In comparison, only 19 per cent of the non-virgins definitely wanted to marry a virgin. One virgin subject was indifferent, but not one of the virgins preferred to marry a non-virgin. Over 35 per cent of the non-virgins were indifferent or preferred to marry a non-

virgin. None of the subjects in the survey definitely wanted to marry a non-virgin. The eight non-virgins who definitely wanted to marry a virgin seem to indicate that our dual standard still is in existence.

Table 14

Virgins' and non-virgins' attitude toward marrying a virgin

Attitude	Virgin	Non Virgin	Total
Definitely yes	8	8	16
Preferably yes	5	19	24
Indifferent	1	12	13
Preferably no	0	3	3
Definitely no	0	0	0
Total	14	42	56

The subjects were questioned as to whether they thought prostitution should or should not be abolished. (Table 15) Only a little over 28 per cent of the virgins were against abolishing prostitution, while 65 per cent of the non-virgins who had never had intercourse with a prostitute were against the abolition of prostitution, and almost 64 per cent of those who had had relations with a prostitute were opposed to its abolition. Many of all three classes were indifferent.

Table 15

Attitude toward whether or not prostitution should be abolished as related to sexual experience

Sexual experience	Yes	No	Indifferent	No answer	Total
Virgins	3	4	6	1	14
Those not having had intercourse with a prostitute but having had intercourse	1	13	6		20
Those having had intercourse with a prostitute	2	14	6		22
Total	6	31	18	1	56



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