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A HISTORY OF PSYCHOLOGY IN KENTUCKY: AN OVERVIEW 1914-1964

FRANK KODMAN, JR.
Murray State College

The history of psychology in Kentucky and elsewhere is a history of the study of man as a biological and social organism. The present treatise will be an overview and not a chronological or definitive history. All histories are selective and never all inclusive. This offering will be more selective and less comprehensive than most due to time and space limitations. The growth of psychology in Kentucky amid a welter of "educational," "behavioral," "social," "paramedical" and even "administrative" concerns is not unlike the paradoxical situation of contemporary psychology elsewhere on the national scene.

A basic reason for studying the history of any science is to review what has been done in order to avoid useless repetition and to take advantage of classic concepts that need to be recast in the light of recent controversy or more definitive knowledge. Since the launching of the first space satellite there has been an increased emphasis on basic prediction, research and theory in psychology as well as in the other sciences. Many psychologists bemoan the vast output of low-level data and much maligned theory even in the most cherished journals and seem to be waiting hopefully for a major discovery or breakthrough to be mad. In medicine, for example, the scientist may readily define his goal as the eradication of cancer, heart disease or cerebral palsy. In a science of human behavior, the goals are not as readily defined. Established in 1892, the American Psychological Association defines its objectives as advancing psychology as a science, as a profession, and as a means of promoting human welfare (1964).

Several Contemporary Issues

A general dissatisfaction with the current state of affairs in psychology leads to disparate efforts and even disenchantment with the discipline. A current controversy is *clinical* versus actuarial or *statistical* prediction (Meehl, 1954). Advocates of statistical predictions call them objective, reliable, scientific and sound. Advocates of clinical predictions call them dynamic, global, sympathetic, genuine and naturalistic. Some psychologists stress laboratory study and some stress field study. Some stress mathematical models of behavior; others stress neurophysiological models. The American Psychological Association itself is currently divided into twenty-four Divisions or sub-specialties. These are general, teaching, experimental, evaluation and measurement, physiological and comparative, developmental, personality and social, society for the psychological study of social issues, esthetics, clinical, consulting, industrial, education, school psychology, counseling, psychologists in public service, military, maturity and old age, engineering, national council on psychological aspects of disability, consumer psychology and philosophical psychology. Divisions may be organized to represent major scientific and professional interests that lie within the Association. The end is still not in sight; other Divisions are being proposed even now. The APA publishes twelve psychological journals which carry only a portion of its members' publications. The remainder of their publications appear in the journals of allied disciplines: education, sociology, medicine, acoustics, statistics, psysiology, engineering, psychiatry, philosophy and many others.

One can readily generate argumentative heat by pitting the "applied" psychologist against his "nonapplied" colleague who seeks after the fundamental tenets of a pure science of behavior. As Marett pointed out in 1912, "there is on the one hand the workaday world in relation to which every community has well established "routine" behavior. On the other hand there is the world of extraordinary events such as disease, death, poverty and crisis." Still further there is the intellectual life of academia where theory and pedagogy preside and woe unto the professor who inclines only towards a concern for the social issues of the times or the welfare of educational, social and economic institutions. Auguste Comte, the famous 19th century philosopher in his *Cours de Philosophie Positive,* adhered to the utilitarian point of view and remarked, "I have a supreme aversion to scientific labors whose utility, direct or remote, I do not see."

Portrait and Profile

A portrait of the scientist, befitting the psychologist and other members of the Academy, is presented by Bernice Eiduson (1962) who describes him as, "a compulsive, hardworking, methodical person whose work is more important to him than anything else in the world, including his family from whom he is very often isolated in childhood or adolescence. He is often unable to distinguish work from play and in any case brings his methodical work habits into his play . . . is bright and open-minded, devoting his life to the discovery of new relationships and content to accept the obsolescence of the old when the newly arrived future requires the abandonment of the past." According to Boring, the noted Harvard psychologist and historian, the able scientist does accept change, for change is his constant goal (1963).

Sanford's profile of the modern psychologist is presented here in abbreviated form (1958).

> A psychologist is an individual who in a wide variety of settings represents and believes in the scientific approach to problems of human behavior. In the laboratory, he spins out theories, formulates hypotheses, tests his ideas, and publishes his results. In the clinic, he does the same thing, employing modified methods in confronting different problems. He believes in the solubility of problems of human behavior. He believes that relevant evidence can be brought to bear on almost any human problem. He is skeptical of dogma, little or big, and has learned to live without the pseudo-comfort of falsely final answers. He is a scientist, in the broadest sense, and subscribes to the morality of science, the morality that puts emphasis on facts, on logic, on objectivity, on testability, on the communicability of knowledge, and the transitoriness of alleged truth. Withal perhaps because of his intimate exposure to the nature of human nature, he has a sensitivity to and appreciation for the human individual, whatever his size or shape or race or creed or color.

In addition to Eudison's portrait and Sanford's profile, the psychologist is first of all an individual heir to the same forces, stresses, anxieties and iniquity of everyman. Whether he masters these when he becomes an expert on behavior is debatable. Frequently the psychologist, who wishes to probe the depths of "inner" or mental life, finds himself relying on his own native store of intuitions, sympathies, judgments, errors and uncommon experience as if a science of behavior did not exist.

The teacher, educator, parent, coach, salesman, minister, manager, diplomat and administrator must also deal effectively with human intangibles. Each in his own way is a student of behavior turning frequently to the works of novelists, playwrights, historians and poets rather than to textbooks of psychology or psychologists themselves. The history of psychology is the history of a discipline striving to establish an identity as a science of behavior translatable into common terms.

To capture the flavor of a history of Kentucky psychology, confined to a finite number of square miles and experienced on a developmental plane, the author finds himself gazing wistfully at his topic and wondering how to synthesize the inner experiences of the participants in the absence of circumscribed records. Psychology conveys different impressions to all those who ask, "What is psychology?" Is psychology really a discipline or is it merely a concatenation of insightful experiences shared by all persons? An unfolding of Kentucky psychology may shed some light on this issue.

Most psychologists would agree generally that psychology is a science of behavior, especially of human behavior and furthermore that it represents a profession and constitutes a body of acceptable knowledge. It is a science insofar as it can meet the rigors of scientific method. It has progressed insofar as it has applied the basic methods of science to the study of human and animal behavior. Universally, man studies man from many vantage points and makes predictions about his behavior and with less intensity, predictions about the behavior of lower animals. The attempt to understand, predict and influence behavior is man's most cherished pursuit.

The science of man is a recent arrival on the stage of history and from its paramount concern with behavior stems interlocking ties with other disciplines. Psychology's distinctive concern is with individual man and his behavior alone or in a group. The social sciences, on the other hand, concern themselves largely with the behavior of groups. More than a modicum of overlap occurs. *Sociology* and *Anthropology* study the origins, extent and meaning of customs among different groups, and man's relation to his cultural history and environment. *Biologists* deal not only with biological processes such as circulation, digestion and heredity but with environmental adjustments such as the nest building behavior of birds, the mating call of various species and so on. Although psychologists are dedicated more to an understanding of learned or acquired processes they also show an interest in unlearned or innate processes. Sensory capacities and their physiological mechanisms are studied by biologists, physiologists and psychologists alike. A knowledge of the relevant aspects of *Physiology* continues to be an essential for understanding behavior. In addition to biology, physiology, sociology and anthropology, psychology recalls a close kinship with philosophy and education. Relevant assertions can also be made to relationships with physics, engineering, medicine, mathematics, statistics, genetics and even pharmacology. A thorough treatment of interdisciplinary relationships is not considered relevant to the present paper.

Lindgren and Byrne (1961) have aptly described the uncertainty and apprehension with which psychology is often viewed. They point out that "it is difficult to imagine a teacher or a grocery clerk having much trouble explaining his work to the public . . . many other professions, psychiatry and law, as well as psychology whose duties and responsibilities are not well known, arouse fear on the part of the public that encounters with members of the profession will lead to exploitation or manipulation without their being able to do anything about it." As our understanding of behavior improves, these fears may not be dispelled, yet a fascination for unraveling the complexity of behavior will undoubtedly continue.

THE NEONATAL PERIOD, 1914-1923

A charter member of the Kentucky Academy of Science, John J. Tigert, was a most versatile academician on the faculty of the University of Kentucky. Dr. Tigert served as a professor of Education before he became Head of the Department of Philosophy. In the 1914-15 University Catalog, his department offered courses in logic, psychology, philosophy, ethics and esthetics. He seemed to be responsible for all of them. In addition, he also taught a psychology course listed under Education. During the period in which he served psychology courses were taught under the philosophy department; the greater emphasis was on philosophy and not on psychology. Nonetheless the catalog description of Elementary Psychology emphasized "fundamental facts and laws of normal consciousness." The lecture course included class demonstrations and experiments. The course in Elementary Philosophy emphasized, "the study of human nature, the extent and force of human understanding, the nature of the ideas we employ and the operations we perform in our reasonings." The similarity between the two catalog descriptions is striking.

In 1917, Prof. Tigert became Head of the Department of Psychology. Courses were listed in Elementary, Advanced Comparative, History, Social and Abnormal. A Psychology Seminar was open to students from education, psychology and philosophy. A year later, General Psychology with a laboratory, Experimental Psychology and Mental Tests were added to the curriculum, also a course entitled The Psychological Clinic. In 1919-20, the department expanded with a new staff member and a new course, Psychology of Advertising.

After holding professorships in education, philosophy and psychology, Dr. Tigert left the University in 1921 and became U. S. Commissioner of Education and later President of the University of Florida. He retired in 1947.

While Dr. Tigert was on leave of absence during 1918-19, Clare B. Cornell became Acting Head of the psychology department. In 1921, another truly remarkable pioneer, Dr. James Burt Miner, assumed the Headship. The Miner Era continued until his death in 1943. A monograph could easily be written on the accomplishments of Dr. J. B. Miner whose influence continues to this day.

Louisville Child Guidance Clinic

At the beginning of this period, 1913 to be exact, the Child Guidance Clinic was established by the Louisville Board of Education which even provided some services to the social agencies of Louisville. In 1917, the Clinic officially became a member-organization of the Welfare League of Louisville, a forerunner of the Community Chest. Following WWI, the Clinic became an independent body incorporated under the aegis of the Louisville Society for Mental Hygiene, a voluntary group of prominent citizens.

Frank Fehring and Melitta Hogg did testing and field work in these early days. In 1922, Dr. Frank J. O'Brien was appointed its first Medical Director. Dr. O'Brien was also a Ph.D. in psychology. He resigned in 1931 to become Asst. Sup't. of Schools in New York City in charge of handicapped children. Dr. John Patterson Currie was also on the staff in 1922. In 1932, Dr. S. Spafford Ackerly, one of Kentucky's most prominent psychiatrists, was appointed Medical Director with professional rank in the School of Medicine's Department of Psychiatry and Mental Heath. After WWII, the Clinic limited its intake to children. Psychologists Ula Strater, Jeanette Burress, Dr. Joseph P. Breiner, Arthur Banton, Gertrude Rieman and Susanne Vutsas were among the earlier staff members.

Dr. Cloyd N. McAllister, a Yale Ph.D. was the first psychologist at Berea College. He joined the Academy in 1917. Morley A. Caldwell from the University of Louisville joined in 1915. Miss Gladys Marie Lowe from U. of K. and Wren James Grinstead from Kentucky State Normal School, Richmond, joined in 1921. James B. Miner came into the organization in 1922 and Karl T. Waugh of Berea College followed a year later.

James Burt Miner

From the recollections of Prof. E. J. Asher (U. of K., 1928-1945), comes the following personal note. "Dr. Miner had a truly outstanding record at Kentucky as far as attracting undergraduate majors and graduate students. He was a great advocate of "clear thinking" and he prided himself on his ability to teach students to "think." He attracted many students to psychology largely because of this emphasis in his classes and in spite of the fact that he was not what most students regarded as a good teacher. In spite of this emphasis or because of it Dr. Miner was or appeared to be very naive as far as everyday motivations and behavior were concerned. In one of his classes in Neville Hall where the front row of seats was very close to the lecture table, Dr. Miner invariably and with ceremony placed his rather large pocket watch on the table. The students closest to the table would reach over, take the watch and set it ahead 10 to 20 minutes. When the set-ahead watch showed 10 minutes to the hour, the students would tell Dr. Miner that it was time for the bell. He invariably picked up the watch, exclaiming "hevens-hevens,' 'and dismissed the class. Hevens-hevens (his version of heaven) was as close to swearing as he ever got. Although this occurred many times during the semester, he seemed not to "catch" on. This immersion in what he was doing led to many instances of "absentmindedness," the most common of which involved looking for his car on campus when he had left it at home or walking home only to discover he had left it on campus. The story goes that he met his son, Horace, on campus one day and said "Good morning, son, how is your father today?" One Christmas he sent a Christmas card to one of his assistants and signed the assistant's name on the card.

From the time Dr. Miner came to Kentucky until his death he was dedicated to the development of psychological services in the community and in the state and in demonstrating that psychology and psychologists could make valuable contributions to the University, the local schools, city government, and state institutions. He worked many hours and drove his own car at his own expense testing or examining freshmen and seniors to show the relation of "intelligence" to school performance. He tested policemen and firemen and children with special problems. Any time he saw or thought he could create an opportunity to demonstrate what psychology could do he was on the job with one or more assistants. Members of the staff, particularly Paul Boynton and I, were caught up in this missionary work. It wasn't long, of course, before the demands for psychological services were too great for the staff to handle. The present acceptance and status of psychology and the early passage of a licensing law in Kentucky can be attributed in large measure to Dr. Miner's dedicated pioneering work."

Early in this period, 1915-16, James Thomas Cotton Noe, in Education, taught Problems of Educational Psychology while Dr. Tigert taught Comparative Psychology under Education. A year earlier, 1914, Dr. Tigert taught Experimental Psychology under Philosophy.

Educational Psychology at the University of Kentucky, following the work of Tigert and Noe was greatly enhanced later by Prof. Clay C. Ross who wrote *Measurement in Todays Schools*: Prentice Hall, 1941. Ross' successor, Herbert Sorenson, has written three McGraw Hill books: *Statistics for Students in Psychology and Educa-*

tion, 1936; *Psychology in Education,* 1940; and *Psychology for Living,* 1948 co-authored with a colleague. His last two books have been widely used in the field. In 1963, *Psychology in Education* was translated in Hindi.

POST-WWI PERIOD, 1924-1932

Professor James Burt Miner, a student of the earlier Cattell, succeeded Dr. John J. Tigert as department head at the University of Kentucky. He was also the 21st President of the Southern Society for Philosophy and Psychology. During his term of office in 1926, the Society met at the University. Dr. Miner's presidential address was entitled, "The Significance of Qualitative Differences in Psychology." He also presented an invited address, "Our Twnety-fifth Anniversary" at the 1930 meeting of the Southern Society. He started the Kentucky Personnel Bulletin in 1932, a bulletin devoted to articles concerned with college personnel problems. He was largely responsible for a registrar's training program leading to a master's degree in psychology; one of the few in the country in the early 1930's. During a leave of absence in Europe 1928-29, Dr. Miner translated Pieron's *Experimental Psychology* into English.

Dr. Miner's broad interests included industrial psychology and he participated in the early development of Interest Inventories. In addition to being head of the department, he was also Director of the University Personnel Bureau. One of the pioneering researches done at the University showed that students in engineering and other areas of study could be differentiated by the pattern of responses shown on interest items. Despite Dr. Miner's efforts, Kentucky was not ready for industrial psychology. Prof. Miner also exerted a positive influence on the development of clinical psychology. He is credited generally with instituting the first entrance examinations for incoming Freshmen at the University.

Prof. Eston Jackson Asher, a former student of Dr. Miner and later a faculty member, organized the Kentucky Cooperative Testing Service sponsored by the Kentucky Association of Colleges and Secondary Schools. Prof. Asher became its director in 1933. He left the University on July, 1945 to become Head, Department of Psychology at Purdue University, a position he holds today. Upon Prof. Asher's departure, the Testing Service was transferred out of the Psychology Department. Prof. Asher authored various versions of the Kentucky Mathematics Test, Kentucky Classification Test, Kentucky English Test and the Kentucky General Abilities Test which were used in high school and college testing programs.

New K.A.S. Members

During the post WWI period, an increasing number of psychologists joined the Academy. These were Miss Anna A. Schneib 1926, Eastern Kentucky State Normal School; Wm. H. Baker, 1926, Berea College; Karl T. Waugh, 1923, Berea College; G. C. Basset, 1927, U. of K.; Clara C. Cooper, 1926, Richmond; John M. Guilliams, 1925, Berea College; James L. Graham, 1927, U. of K.; and R. G. Will, 1928, Centre College, Danville. Others who joined were Noel B. Cuff, Eastern Kentucky Teachers College; Ellis Freeman, University of Louisville, Milton B. Jensen, Fort Knox, J. L. Leggett, Transylvania College and W. F. O'Donnell, Richmond. The distinguished psychologist and statistician, *Carl S. Spearman* of the University of London was made an honorary member of the Kentucky Academy of Science in 1931.

Staff Transitions at U.K.

Gladys Lowe Anderson, Paul L. Boynton, G. C. Basset, J. L. Graham, Henri Beaumont and others came and then moved on. Courses in psychology were continuously added, revised and some dropped–much like the process going on today. In 1930, three new faculty members, M. M. White, Graham B. Dimmick and Edward Newbury came on the scene. Applied psychology, clinical psychology and "free thinking" were greatly enhanced. A potent trio to say the least. One of these men was assigned courses in experimental psychology, learning, mental work and fatigue, the emotions, the observation process, and the psychology of language.

Animal Behavior Laboratory

Recollections from a dyed-in-the-wool animal psychologist, University of Kentucky. Along about 1930, a Carr-type maze was found tucked away in the Physiology Department, then housed in Miller Hall. The animal lab began in a small room at the top of the stairs on the third floor of Neville Hall with the use of an adjoining room for recording equipment. There were no vivarium facilities but there was a rat colony in the Small Animal House of the Home Economics Department.

Next, three rooms were occupied in the Physiology Department's Animal House on the site now occupied by the Home Economics Building. One room was large enough for a Tolman-Nyswander maze. A swimming tank was installed gratis in one of the two remaining rooms. These modest facilities constituted the first animal behavior laboratory at the University. Several years later, the first animal course was taught with a laboratory. In 1939, a laboratory course in animal psychology was reported at the Southern Society for Philosophy and Psychology in Durham. Shortly thereafter, the animal lab moved to the basement of Neville Hall and remained there until the building was gutted by fire.

Master's theses in animal behavior were completed by A. Dudley Roberts, Robert A. Baker, Carson Y. Nolan, Joe Mock, James Clark, and others. Among the students who had the lab course and some who were assistants were Lee S. Caldwell, Lelon Peacock, Conan Kornetsky, Jake Karraker, Jacob Silverberg and Jane Haselden to mention a few.

Some of the topics investigated were: the basis of a goal gradient or symbolic mediation in discrimination learning, changes in body state during repeated work performance, body temperature and work performance, effects of adrenalin, LSD 25, effects of audiogenic seizures on the oestrus cycle; sodium chloride preference during and after deprivation, water behavior and vestibular disease and wheel activation following forced inactivity.

More History

Prior to 1933, psychology at the University of Louisville was wedded to the Department of Philosophy in the Division of Natural Sciences within the general framework of Arts and Sciences. This same year, the first Ph.D. degree in psychology was given at the University of Kentucky and R. S. Hake, Morehead Teachers College and Fred L. Jones of Picadome High School, Lexington, joined the Academy of Science.

In the 1930 records of the American Psychological Association, the following Kentucky psychologists were listed: T. A. Hendricks and C. N. McAllister, Berea; C. B. McMullen, Danville, E. J. Asher, G. C. Basset, P. L. Boynton, J. L. Graham and J. B. Miner, Lexington; G. M. Ulvin, Louisville; R. L. Hoke, Morehead and C. C. Cooper and N. B. Cuff at Richmond.

Dr. M. L. Billings became head of the Psychology Department at Western Kentucky State College, Bowling Green, in 1926. He held this position until his death in 1950. During this period, the department was to a large measure, a service department for the teacher training program.

POST-DEPRESSION PERIOD, 1934-1943

Early in this period, five new psychologists joined the Academy of Science. These new members were Dr. Lawrence M. Baker, Berea

College, Berea; Dr. M. L. Billings, Western State Teacher's College, Bowling Green; Clio Arnold, Sue Bennett College, London; Dr. Graham B. Dimmick and Martin M. White, University of Kentucky, Lexington.

Lexington Child Guidance Clinic

The Child Guidance Service, Lexington, Kentucky was established in 1934 as a community project of the Lexington Junior League. Dr. Betsy Worth Estes served as the first Junior League Chairman of the project. The Clinic actually began in Neville Hall, the early home of the Psychology Department. The staff consisted of a Director and a part-time assistant. It was the general purpose of the founders to provide diagnostic, consultive and treatment facilities for a wide range of mental health and adjustment problems of children. From 1934-1940, a total of 1,269 children were treated by a small, but dedicated staff.

Children are referred for evaluation and treatment for the following reasons:

1. Nervousness and emotional instability, exaggerated fears, hostility, stubbonness or hyper-sensitiveness.
2. Unsatisfying personal and social relationships, excessive timidity, isolation, withdrawal from contact with others, too much day dreaming or inability to maintain attention on anything.
3. Disturbed sleep, unhealthy eating habits or bed wetting.
4. Difficulties in psychosexual development.
5. Aggressive and anti-social behavior, disobedience, lying or stealing.
6. Mental incompetence, mental subnormality or immaturity in emotional development.
7. Dislike of school and failure in school work or problems of proper placement in school.
8. Identification of children with superior learning ability.

For over thirty years, the Director of this clinic, Dr. Graham B. Dimmick, affectionately referred to as the "Dean of Clinical Psychology" in Kentucky, has divided his time between the agency and his graduate teaching at the University. Prof. Dimmick, a highly respected expert in clinical psychology and the use of the Rorschach test, has treated over 6,000 children and significantly influenced a generation of graduate students at the University of Kentucky.

Clinical Psychology, U.S.P.H.S. Hospital

The U. S. Public Health Service established a hospital in Lexington for the treatment of narcotic drug addicts in 1935. Ralph R. Brown was the first research psychologist at the hospital from 1935-1942. He received his Ph.D. degree from the University of Kentucky in 1938. John E. Partington who received his M.A. degree from U. of K. in 1938 was also a research psychologist from 1935-40. The clinical psychology service is under the Division of Hospitals. Dr. Brown studied the general intelligence of narcotic drug addicts, the effects of drug addiction on personality, performance under the effects of drugs and the effects of drug addiction on personality.

The hospital has an Addiction Research Center which is separate from the Division of Hospitals. Psychologists are assigned to the Center from the National Institutes of Mental Health. The staff carry on an active research program of a multidisciplinary nature. They have developed psychological scales to evaluate the effects of drugs and are widely recognized for their research studies of pain.

During this period, E. J. Asher continued to publish the results of his investigations of intelligence and academic achievement. In 1935, he reported his study of the I.Q. regression of Kentucky mountain children, now regarded as a classic in the field. With the passage of time, these children seemed to perform at a lower intellectual level.

At the 25th meeting of the Academy of Science in 1938, no new psychology members were noted. The Kentucky Psychological Association was, however, listed as one of the affiliated organizations and Noble H. Kelley was chairman of the Division of Philosophy and Psychology. The meeting was held at Morehead State Teacher's College. Edward A Newbury read a paper on "The Dynamics of Instincts" and Noble Kelley read a paper entitled, "A Study of Presbyacusia."

Eastern State Hospital, Lexington

On October 1, 1938, Dorothy Cleek came to Eastern State Hospital as a Student Psychologist. She was the first to afford any psychological services at this hospital. Miss Cleek arrived years before the Trainee Program was initiated and stayed until September 30, 1943. In the immediate years that followed psychological services were very few. Dr. W. E. Watson, Supervising Psychologist for the Division of Hospitals and Mental Hygiene, Kentucky Department of Welfare, came occasionally upon special request. By 1950 three other students had each worked part-time a year or two. These included Martha Ringo, David Orr, and William Nagge.

Kentucky Psychological Association

The Kentucky Psychological Association was formed in the 1930's and became affiliated with the American Psychological Association in 1939. During its early years, the Association was headed by an elected chairman. Later, the membership elected a president, secretary-treasurer and two directors. Most of the past presidents are still in the state and some have headed the organization more than once.

Kentucky State Hospitals

A survey of state hospitals in Kentucky was conducted by the Mental Hospital Survey Committee, 50 W. 50th St., New York, in 1938. The report concluded that, "the state hospitals have no psychologist, either resident or consulting. Psychological examinations at the State Institution for the Feebleminded must be made by some member of the teaching staff. A competent clinical psychologist can make a considerable contribution to the understanding of mental patients."

A year later, a survey by the U.S. Public Health Service in Washington reported that, "Some psychological service is given at the Eastern State Hospital by a student from the state University. This psychologist also examines candidates for the position of attendant, thus checking on the impressions of the medical officer and the supervising nurse who are responsible for making selections. The school for mental defectives now has a very competent staff psychologist and in time will supply him with the needed tools of his trade. There is also a psychologist attached to the central office, whose duties are principally in the penal and correctional institutions, but who can give some service at the state hospital if it is needed."

Regular but limited clinical psychological services first became available at Central Hospital in the late 1930's. One psychologist was employed by the Department of Welfare (of which Central Hospital was a part) to visit various institutions periodically to examine referred cases. He visited this hospital about once a month.

APA Members from Kentucky, 1940

The APA directory shows the following members in 1940. P. L. Hill, *Anchorage;* L. M. Baker, *Berea;* M. L. Billings and L. M. Johnson, *Bowling Green;* C. B. McMullen, *Danville;* H. V. Bice, *Frankfort;* E. J. Asher, H. eaumont, R. R. Brown, A. A. Capurso, L. W. Croft, G. B. Dimmick, J. P. Key, C. C. Limburg, J. B. Miner, E. Newbury, M. MacL. Ratliff, C. C. Ross, C. E. Thompson, D. S. White, and M. M. White, *Lexington;* K. A. Anderson, C. H. Crudeen, M. B. Jensen, N. H. Kelley, E. H. Scofield, G. M. Ulvin, L. W. Whisler, *Louisville;* J. D. Falls, *Morehead;* W. D. Lewis, *Murray;* J. W. Curtis, *Pikeville;* and N. B. Cuff, *Richmond.*

In 1940, January 17, Dr. M. M. White, of the University of Kentucky gave a series of lie detector tests at Neville Hall to suspects in the murder mystery of a 78 year old woman from Franklin county. Major Joe Burman of the State Bureau of Identification accompanied the suspects.

Army Medical Research Lab, Fort Knox

The U.S. Army Medical Research Laboratory was established at Fort Knox, Kentucky, 1 September 1942, as a combined effort of the National Research Council, The Surgeon of the Armored Force and The Surgeon General of the U.S. Army. It was designated the Armored Medical Research Laboratory with the primary mission "to study the physical and mental stresses placed upon the soldier in the operation of armored vehicles with the object of improving safety and efficiency." The present Psychology effort, as distinct from the laboratory as a whole, was initiated in 1950. Dr. R. Y. Walker, Dr. John F. Corso and Dr. George S. Harker, constituted the original staff. Within a general, medical and life science laboratory, the mission of this group was essentially that of the original laboratory with the exception that the renewed effort was in support of an Army-wide human factors program.

The Psychology Division has had a succession of five directors. Dr. Walker, the original director, was followed in turn by Dr. Arthur J. Riopelle, Lt. Col. Ernest K. Montague, Dr. Fred E. Guedry, and the present director, Dr. George S. Harker. The initial efforts of the Psychology Division were in the fields of audition and binocular vision. These areas of research have been supplemented by major studies of the vestibular sense, complex motor skills, ergonomics, and psychopharmacology. The staff presently consists of 12 professional workers, six of whom are civilian and six of whom are in uniform as professional Army scientists. These researchers are supported by an equal number of military technicians. Technical support within the laboratory includes machine, wood, and electronic shops as well as primate and small animal colonies. Current research extends from the psychophysics of human responses to sensory stimulation to animal behavior and neurophysiological recordings.

POST-WWII PERIOD, 1944-1953

In 1946, the U. S. Public Health Service gave a grant of $4,500.00 to the University of Kentucky department of psychology for expansion of its clinical psychology program. Three part-time instructors were hired, two psychiatrists and a clinical psychologist.

In the summer of 1948, Dr. Robert L. Milisen, Speech Pathologist, from Indiana University was hired to teach two speech therapy courses at the University. A $400.00 grant was given by the Lexington Chapter of the National Council of Jewish Women. These courses served as the stimulus for the Speech Center and the Speech Pathology training program.

The Department of Psychology and Social Anthropology at the University of Louisville began offering the master's degree in psychology in 1949 and to date has graduated over a hundred students from the program. A year earlier the department was given its present title and shifted from the Division of Natural Sciences into the Division of Social Sciences.

VA Hospital, Lexington

The florescence of Psychology which accompanied its use by the military in both World War I and World War II had as one of its consequences in Kentucky the Veteran's Administration Psychology Training Program. To help train psychologists to fill the expanded demand, the Veterans Administration in 1946 began a national service-subsidization program. Dr. M. M. White, then Head of the University of Kentucky Psychology Department and Graham B. Dimmick, Director of the clinical training program saw to it that the University was one of the sixteen pioneering institutions in the country to install the cooperative program. Dr. Lawrence Baker took the first psychology position in the Lexington VA Hospital which had been in existence since 1931. One of his principal duties was to supervise a dozen trainees. When Dr. Baker moved on to a teaching position at the end of his first year, A. Dudley Roberts was brought in as Chief of Service, a position he has occupied ever since. The number of trainees subsequently rose to a maximum of 21 but through the years has averaged approximately 14 to 15.

The joint program between the University of Kentucky and the VA Hospital, Lexington, Kentucky has been one of the more rewarding in the nation. To the date of this writing, 62 trainees have completed Ph.D. requirements. One of its graduates, Cecil P. Peck, was appointed Chief of all VA psychologists in the country in 1951. At the VA Hospital, the trainee has received supervision and guidance in diagnosis, therapy, counseling, and research as a meaningful supplement to his academic courses. The growth of the staff has mirrored the growth of psychology in the state and in the nation. The gradual and still continuing expansion has brought a current total of ten psychologists to work under the direction of the Chief. Some of their energies are devoted to the training and research functions and to an assortment of services fitting the enlarging concept of what psychologists can do. The University of Kentucky has sent two post-doctoral trainees to the program.

Phenomenology

Because of the presence of Erwin W. Straus, M.D. on the staff of the Lexington Veterans Administration Hospital in 1946, Kentucky became one of the centers of phenomenological inquiry into the problems of psychopathology. His influence permeated the setting, influencing the development of thought of trainees and staff. Through the years some psychologists have become his close disciples.

In the early stages of this period, the Kentucky Psychological Association and the Kentucky Education Association sponsored joint programs at the annual meeting of K. E. A. Psychologists and educators attempted to tackle some of the major issues in education. When K. E. A. requested K. P. A. increase its membership in K. E. A. to fifty percent or more, the cooperative venture fell by the wayside and has not been renewed to this day. Psychologists and educators are as prone as other professionals to succumb to the common disease known as "Rigor Categoris" (label coined by the author) and defined as "hardening of the categories."

Guidance Center, Catherine Spalding College

In 1944, the forerunner of the Psychological Service and Guidance Center was established at Nazareth College, now known as Catherine Spalding College. The Center has been under the expert supervision of Sister Agnes Lucile Raley, one of Kentucky's pioneer psychologists. Courses were set up in 1942 to meet the needs of students majoring or minoring in psychology, education students needing basic psychology courses and student nurses needing specific psychology courses. Clinical psychology as a course was offered for the first time in 1944. Speech correction services were also added this year.

In 1953, the Guidance Center assumed the responsibility for the Educational Guidance Clinic of the Catholic School Board for two years. During this two-year span, a research study of superior children was undertaken. Another study dealt with children's performance on the Bender Gestalt Visual-Motor test. Also in 1953, the Center assumed the responsibility for a remedial reading program.

Reading programs have been initiated by the Center in nearby schools.

Louisville School Systems

The Catholic School Board (Parochial School System, Archdiocese of Louisville)employed their first full time psychologist, Miss Dorothy McGuire, on September 12, 1947. The essential work of the school psychologist was testing and evaluation of children with academic problems.

VA Hospital, Louisville

The Clinical Psychology Section of the VA Hospital was established somewhere around 1947 at Nichols Hospital with Miss Priscilla Alden as Acting Chief. Miss Alden resigned in 1949 at which time Joseph Lawson became Acting Chief while still a trainee from the University of Kentucky. Miss Alden initiated a program by which psychiatric residents were trained to administer abbreviated Wechsler-Bellevue tests to patients and, in conjunction with her successor, established the VA as a field placement for masters' degree students from the University of Louisville. Some eleven such students were trained—among them Raymond Bixler, currently head of the Department of Psychology at the University of Louisville; and Clarence Amster, on the faculty of the University of Louisville.

From 1950 to 1951, Joseph Lawson was Acting Chief. In March, 1951, Vera Kennedy became Acting Chief with Mr. Lawson on the staff still working on his doctorate. During the period from 1947 to 1951, Drs. Arthur Benton, Graham Dimmick and Arthur Weider were consultants to the section. In December of 1951, Joseph Lawson became Acting Chief of the Psychology Section and Dr. Vera Kennedy was Asst. Chief. He became Chief in 1953. Early in 1954 along with Dr. Kennedy, a Research Psychologist, Dr. Herman Efron was added to the staff. Dr. Efron was employed specifically to do research in Gerontology and especially on the possibility of therapeutic effects of Histamine and Nicotinic Acid on cerebral arteriosclerosis. Throughout this time, clinical psychology had stressed the psycho-diagnostic role importantly, although supervising clinical psychology Trainees from the University of Kentucky was also a part of the function. Such students as Arnold Krugman, Louis Brown, Robert Nichols, Jay Chambers, *et al,* spent some time in the Clinical Psychology Section.

Psychology Licensing Law

The 1948, Kentucky Revised Statutes, Chapter 319 was the first psychology licensing law passed by any legislature. This law is a restrictive form of licensing legislation. Restrictive licensing in effect says, "anyone doing these things is, ipso facto, practicing psychology no matter what he calls himself and comes under the purview of the law." The law required the formation of a State Board of Examiners of Psychology. The first members of the Board of Examiners were Dr. Walter E. Watson, chairman, George A. Muench, sec'y. Leroy Billings, Graham B. Dimmick and Frank A. Pattie.

On January 15, 1949, seventeen psychologists were certified under Kentucky's first psychology licensing law. They were as follows: George A. Muench, Marion Billings, Graham B. Dimmick, Frank A. Pattie, Walter E. Watson, C. W. Swink, Priscilla Alden, Susanna Reynolds, Noble H. Kelley, Milton B. Jensen, Pauline Klinger, Herbert H. Humphreys, Nancy T. Collins, Ray Bixler, Harold E. Block, Paul H. Bowman and Jessie Irvine. Fifty-three licenses were issued between 1949-1963.

Kentucky Department Mental Health

The Kentucky Department of Mental Health was established as a separate and distinct department in 1952. Psychologists have played increasingly important roles in the diagnosis and treatment of the mentally ill in Kentucky. In 1952, there were seven psychologists in the new department. Today there are seventeen full time and five part-time psychologists. In 1952, a psychologists' chief function was diagnostic testing. Today the areas of responsibility include diagnosis, planning, group and individual psychotherapy and research. Currently, there are three Directors of Research in the state mental hospitals. All of these directors are psychologists and plans are underway to recruit Directors of Research for the other hospitals in the department and for the two institutions for the mentally retarded.

University of Kentucky

During the period, 1947-1952, the psychology department operated a testing program at the sub-regional office of the VA on Main Street, downtown. Prof. Edward Newbury, with the aid of a number of graduate assistants, carried the major responsibility for the testing and counseling of veterans under the G. I. Bill shortly after the contractual arrangement was worked out with the Advisement and Guidance Section of the V. A. The Unit was originally headed by R. D. Johnson with C. R. Hager as adviser.

On July 1, 1950, Jessie Irvine was transferred from the Central Office of the old Division of Hospitals and Mental Hygiene to Eastern State. She was the first full-time psychologist there. For approximately two years, however, she worked more in Personnel and actually had the title of Personnel Officer. On September 1, 1951, she was joined by E. A. Moles and S. J. Cornett. Dr. Moles is now Consultant for the Department of Mental Health and Dr. Cornett is with the Department of Health, Education, and Welfare in Charlottesville, Virginia. Through the years several other students have worked at Eastern State Hospital part-time. Among these were Lawrence Oberc, Ruth Carroll, Joan Lee, Jerome Klein, William Query, Lauraine Stewart, and James Gay. Nicholas DePalma, Cardestral McGraw, and Allie Hendricks have worked full-time.

More Psychology at Fort Knox

The Armor Human Research Unit authorized in November 1951, at Fort Knox is a division of the Human Resources Research Office, (HumRRO), George Washington University. A contract between the Department of the Army and the University makes the research possible. The research office is composed of five research units—Air Defense, Armor, Infantry, Leadership and Aviation and a Training Methods Division. Almost all of the research scientists on the staff are experimental psychologists. Most of their research is aimed at increasing the effectiveness of men and weapons. One of their studies, for example, has dealt with human factors which determine effective command and control. The research unit at Fort Knox, the oldest field research group, is considered one of the nations most important military research organizations.

Dr. Norman Willard, an experimental psychologist, was promoted to his present position of Director of the U.S. Army Armor Human Research Unit on November 10, 1958. In 1961, he was elected President of the Kentucky Psychological Association. His immediate predecessor in the Unit was Dr. Howard H. McFann who moved on to the directorship of research at the Army Leadership Human Research Unit in California. The Fort Knox Unit was opened by the late Dr. Harry W. Braun with a staff of four researchers. Psychologists at Fort Knox and other installations as well lecture in nearby colleges and Universities. Many participate actively in the affairs of their community.

CONTEMPORARY PERIOD 1954-1964

Since 1954, at the VA Hospital in Louisville, there have been numerous Clinical Psychology trainees—most of them from the University of Kentucky, but others from Purdue University, the University of Indiana, and Vanderbilt University. With the exception of the increased emphasis on psychotherapy in all of its aspects and more active participation in the team approach, no significantly new programs have been established. In 1960, the Vocational Counseling program was added to the function of the Clinical Psychology Section and this, while initially a separate Service, has now become a coordinate responsibility of the Chief of the Clinical Psychology Section, dynamic Mort Leventhal.

In recent years, Clinical Psychology has played an increasingly active role in the hospital as a whole. Membership on various boards and committees—such as the Disciplinary Board, Training Committee and Rehabilitation Board have been assigned to the staff. More recently, the Chief of the Section Dr. Leventhal has been designated Shelter Manager for the hospital's fallout shelter program and has been trained at the Civil Defense Staff College in Battle Creek. Also, numerous lectures and training sessions to volunteers, nurses and attendants have been requested of the staff. Both of the staff members hold faculty rank in the University of Louisville Medical School and participate actively in the teaching of medical students, psychiatric residents, and psychological interns.

During the tenure of Dr. James S. Calvin as Head of the Department of Psychology at the University of Kentucky, 1950-1963, the department developed its full strength academic program and in 1954 was accredited by the American Psychological Association following a comprehensive 'on the spot' evaluation of the total program. The staff doubled in size and the full-time faculty now number 14-15 members; excluding part-time staff and joint appointees from other departments. Since the inception of the Ph.D. program, over two hundred candidates have been graduated. U.S.P.H.S. graduate trainee stipends began after the department was accredited in 1954, and in 1956, a graduate trainee program was initiated between the department and the State Department of Mental Health. Coursework in speech pathology and audiology were added during this period and the department developed a Speech Center and an Audiology Clinic. The department gained considerable strength in experimental, clinical and social psychology.

From 1950 to 1956 at Western Kentucky State College, the psychology department had no formal head. In 1956, Dr. C. H. Jaggers became chairman and remained in this position until his retirement in 1960. It was during this period that the department first offered a minor to students who were in the Arts and Science curriculum. Dr. Charles L. Shedd became the third head in 1960. Since 1961, students have been permitted to take an undergraduate major in psychology. The department now offers a total of 57 hours. There are five full time staff members and three part-time. All full-time members have the doctorate.

At the 1954 meeting of the Southern Society of Philosophy and Psychology, E. E. Cureton presented . . . the report of an *ad hoc* committee to consider the formation of a Southeastern Psychological Association. Many members of the Kentucky Psychological Association attend SEPA meetings or are members of the organization.

In 1954, two fully trained clinical psychologists were working at Central Hospital. The first regular position for a psychologist was established in 1950 and filled by a graduate student from the University of Louisville. A few students from the University of Kentucky have received clinical experience at the Hospital. From the middle 1950's to 1960, two to three full time positions have remained unfilled. Recruitment seems to be a problem. At present, the Director of Research at the hospital received his doctoral level training in experimental and social psychology.

On April 14, 1955, there was a joint meeting of KPA and KEA at the Warren Memorial Presbyterian Church in Louisville. A year later KPA preesnted a panel discussion on, "A critical examination of the use of scientific psychology in modern education." Now these two organizations no longer seek the mutual pursuit of educational issues. Also in 1955, the Southeastern Psychological Association, which attracts many Kentucky psychologists, became affiliated with the American Psychological Association.

In 1957-59, the staff of the Guidance Center and Psychological Service at Catherine Spalding College was expanded to assist in training Guidance Counselors. In 1959, the Center assumed the responsibility for the Placement Bureau. That same year, the Center developed a service known as the Parentarium—a group guidance conference between counselors and parents. Sister Agnes Lucile Raley, the pioneering director of the Center, holds a Ph.D. in psychology from Fordham University. Workshops and Guidance Institutes are sponsored regularly by the Guidance Center and its staff. The Director has served consistently on the State Board of Psychological Examiners and as KPA's representative on the Kentucky Children's Advisory Council.

The Jefferson County School System (Board of Education) employed their first full time psychologist, Mr. O. L. Shields, in September, 1957. The essential task for the school psychologist in this system is to evaluate the academic placement of children and work with special education and accelerated classes. Thus, in the Louisville area the Louisville Public School System, the Jefferson County School System, the Parochial School System, and Ormsby Village are agencies that employ school psychologists.

During 1959-61, Kentucky's internationally known authority on hypnosis, Prof. Frank A. Pattie, served as President of the American Society of Clinical Hypnosis. At that time the Society had 2,184 members, including 1,471 physicians, 627 dentists and 86 psychologists. The Society is a member-organization of the World Federation for Mental Health and an affiliate society of the American Association for the Advancement of Science. Since 1958, he has served as an associate editor of the American Journal of Clinical Hypnosis.

Ernest Meyers Award

As a memorial to the late Ernest Meyers, beloved colleague and instructor of students, the annual *Ernest Meyers Award* was established by action of the Executive Council of the Kentucky Psychological Association at its meeting on August 3, 1957. It voted to award twenty-five dollars to the undergraduate student of any senior college or university in Kentucky who presented the best paper or report on his research. The first committee consisted of Dr. M. M. White, Chairman, Christine Ballmann, R. M. Griffith, and Jessie Irvine. Later Chairmen have been Louis Brown and Robert A. Baker. It is believed by many that this represents one of the most laudable actions of the Association.

University of Kentucky Medical Center

The first member of the profession of psychology to join the staff of the University of Kentucky Medical Center was a research psychologist employed in the Department of Behavioral Sciences in 1959, one year prior to the admission of the first class of medical students. A director of clinical psychology for the Department of Psychiatry, who was added to the staff in 1960, assumed the responsibility of adding new psychologists to that Department, filling two positions in the area of clinical psychology and one research position in the area of neurophysiology.

The members of the clinical psychology staff have rendered services and supervised graduate students in the areas of diagnostic evaluation and psychotherapy. The patient population has included persons in outpatient and inpatient psychiatric services, in pediatrics, medicine, surgery, and rehabilitation. Contacts with other units of the hospital have expanded as the Hospital has developed.

Each of the psychologists has been involved in research activities, and, in some instances, in larger projects which are of immediate practical value in the hospital setting.

The psychologists have also taught in several conjoint courses developed for medical students and have maintained contact with the Department of Psychology in the College of Arts and Sciences through joint appointments. Positions for research psychologists and clinical psychologists will become available as the size of the staff expands.

Central Kentucky Psychological Association

In the fall of 1962, interest was revived by psychologists in and around Lexington in forming a local organization. In response to the idea, some 50 local psychologists met at the Holiday Inn Restaurant in Lexington and decided to form an organization to be called the Central Kentucky Psychological Association. Dr. Jesse G. Harris was elected its first President. There were 65 charter members. The minimal qualification for members was a master's degree in psychology or near completion of the degree. Affiliates could be students or other persons interested in psychology. Meetings have been held every two months except in the summer.

During 1962 a half dozen psychologists were attracted to positions in the Lexington VA Hospital in order to participate in seminars delving in depth into the seminal ideas of Dr. Straus, of Husserl and Heidegger and other leaders of the Movement. A conference held in 1963 on *Phenomenology: Pure and Applied* brought together an international field of speakers and an audience of 500 people from 26 states. The proceedings of that Conference are to be published during 1964 by Duquesne University Press and will be followed by a second conference on *Phenomenology of Will and Action* in May of this year.

The Clinical Psychology staff of Eastern State Hospital at present consists of Miss Irvine, Director, Billie Corder and Marie Garner. Robert DeBurger came in 1963 as Research Psychologist. Diagnosis was the only area of work, except personnel, of the Psychologists until the creation of the Kentucky Department of Mental Health in 1952. In 1953 Group Psychotherapy was added and later individual Psychotherapy. Now for approximately two years staff members have engaged in research and instruction for student nurses. Since last autumn vocational evaluations of mentally ill patients have been added to the activities.

In 1963 the University of Louisville began to use resources of Central Hospital in their course in experimental psychopathology.

With clinical psychologists here exercising the full range of their skills, psychological services are represented in considerable variety. Graduate psychology students and sometimes other students have had summer appointments for the past few years, always with work for or in collaboration with the clinical psychology section. For the most part they have helped with research projects or acquired experience for psychological internship credit.

In September, 1963, a Ph.D. program was approved in clinical psychology and in experimental psychology at the University of Louisville. Twenty-two candidates were admitted and twelve more are being considered for 1964.

Psychology Manpower Conference

In 1963, the Kentucky Mental Health Manpower Commission sponsored a Psychology Manpower Conference in Louisville stressing state and University cooperation in the training and recruiting of psychologists for public mental health programs. Thirty-eight psychologists attended. The two University department heads stressed their emphasis on scientific psychology.

Kentucky APA Representation

In 1960, there were one hundred thirty-one Kentucky psychologists holding membership in the American Psychological Association. In 1950, there were sixty-seven members; in 1940 thirty-two members; in 1930 twelve members, in 1920 two members and in 1914 only one member. The two earliest members were Cloyd McAllister and Karl T. Waugh of Berea.

Modern Research in Psychotherapy

A program of research into the processes and outcomes of psychotherapy was begun with the initiation of the Psychotherapy Research Group in the Department of Psychology at the University of Kentucky in 1963. The initial aspect of the research involves an intensive study of 320 patients undergoing group psychotherapy. Also, data from the Wisconsin program was transferred to the University of Kentucky to continue the attempts to carry out research in individual psychotherapy with schizophrenics.

A model training program integrating didactic and experiential approaches to the training of counselors and psychotherapists was developed during the 1963-1964 year as part of the program of the Psychotherapy Research Group. A portion of this program involved the training of lay therapists and an evaluation of their effectiveness based not only upon process measures but upon their effectiveness with 100 treatment and 100 control patients at Eastern State Hospital. The Psychotherapy Research Group has also been involved in initiating research supported by the Federal Government cooperation with the College of Education, Division of Special Education in the State Department of Education, the Frankfort State Hospital and School and the Stuart Home School for the Mentally Retarded; representing joint efforts with the Veterans Administration Hospital in Lexington, the Kentucky Village male and female juvenile delinquent facility, Eastern State Hospital, and the State Hospital in Danville. Members of the Psychotherapy Research Group were also active in initiating plans for a proposed Mental Health Research Institute which wolud encompass research activity in mental health throughout the Commonwealth of Kentucky. The Psychotherapy Research Group sponsored the training in psychotherapy of the Department's first NIMH Post-Doctoral Research Fellow.

Research Grants

Nowadays, it is fashionable to seek Federal or Foundation support of research endeavors; the larger the grant, the greater the prestige. Dr. Steven Vandenberg, psychologist, Department of Pediatrics, Louisville School of Medicine recently received a four year grant of $280,000.00 from the National Institute of Child Health and Human Development entitled *The Louisville Twin Study*. Dr. Earl Alluisi and Dr. Samuel Fulkerson, Department of Psychology, University of Louisville are working on a $143,000.00 grant from the Army Medical Research and Development Corps. The study deals with psychological reactions to infectious diseases. Dr. Charles B. Truax and Dr. Robert Carkhuff, Department of Psychology, University of Kentucky received a 1963 grant of $138,000.00 from the National Institutes of Mental Health concerned with research into the processes and outcomes of psychotherapy.

Closing Comment

Earlier in this paper, the objectives of the American Phychological Association were stated. Its three-fold purpose—advancing psychology as a science, as a profession and as a means of promoting human welfare are clearly reflected in this brief history of Kentucky psychology. The introductory section of this paper was intended mainly for the other disciplines in the Academy. The contemporary issues facing Psychology are merely symptoms of a growing discipline and reflect careful critciism and insightful analysis. Most psychologists have a healthy respect for their discipline whether they are "clinical" or "experimental," "applied" or "nonapplied." Understanding human behavior is perhaps our most urgent scientific goal.

It now remains for somone to undertake the complete history of Kentucky psychology. The author extends his grateful appreciation to all those who contributed information and encouragement. Regrettably, certain errors and misinterpretations have undoubtedly occurred; for these the author takes full credit. The task though brief was enjoyable and rewarding. Everyone can be proud of the history of psychology in Kentucky. The next fifty years should be even more fruitful.

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FIFTY YEARS OF PLANT PATHOLOGY IN KENTUCKY

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The history of Plant Pathology in Kentucky necessarily is concerned with the history of the Kentucky Agricultural Experiment Station. In the early years plant disease problems were the concern of the "crops" departments, Horticulture and Agronomy and the "regulatory" department, Entomology and Botany. The last was under the leadership of Mr. Harrison Garman from 1889 to 1928.

Mr. Garman can best be described as an old fashioned naturalist, one interested in all kinds of life and what little was done to help farmers with their plant disease problems until after World War I was done largely by him. His service consisted of diagnosis of diseases, identification of some of the pathogens involved, and recommendation of remedies when they were known. Research on plant diseases, as it developed later and as we know it today, was not part of the early program. In 1918 the first person recognized as a plant pathologist, Miss Mable Roe, was employed for one year as Assistant Plant Pathologist in the Department of Agronomy.

In the fall of 1919 W. D. Valleau, who had just received his Ph.D. degree from the University of Minnesota, was employed as Plant Pathologist in the Department of Agronomy and the beginning of plant pathology in the sense of a discipline, functioning in research and teaching, in the Kentucky Agricultural Experiment Station and the University of Kentucky can truly be said to have occurred with this appointment. It is interesting that with 2 exceptions, all of the people concerned with plant pathology in Kentucky since that time, are still on the faculty of the University of Kentucky.

In 1923 E. M. Johnson was hired and he later received the Ph.D. degree from the University of Minnesota. In 1931 Lawrence Henson joined the staff with a joint appointment as plant pathologist and forage crop agronomist. He later undertook advanced study, also at the University of Minnesota. Dr. H. H. Thornberry (Ph.D., Minnesota) joined the staff in 1936, but remained for only one year. Dr. Stephen Diachun (Ph.D., Illinois) was added to the group in 1937. In 1950 J. L. Troutman was employed as Assistant in Plant Pathology and remained in that position until 1953 when he left to undertake advanced study at the University of Wisconsin. Also, in 1950 Dr. R. A. Chapman (Ph.D., Illinois) joined the staff and in 1953 Dr. G. W. Stokes (Ph.D., Wisconsin) was hired.

The latest additions to the staff were Dr. R. E. Hampton (Ph.D., Wisconsin) in 1960; Dr. R. A. Reinert (Ph.D., Wisconsin) in 1962; C. C. Litton (Agricultural Research Service, United States Department of Agriculture) in 1962; Dr. J. W. Oswald (Ph.D., California) in 1963. In 1961 Dr. Valleau was given special assignment.

On July 1, 1963 plant pathology was removed from the Department of Agronomy and the Department of Plant Pathology was formed with Dr. R. A. Chapman as Chairman.

From 1919 to 1936 Plant Pathology was located in the Experiment Station Building but in 1936 it was removed to a new building named the Tobacco Research Laboratory. Here, in addition to plant pathology activities, curing studies on burley tobacco were conducted by Dr. R. N. Jeffrey and Prof. L. S. Obannon for a period of 10 years.

The purpose of the remainder of this paper is to report in brief the contributions that have been made by members of the staff in the general area of plant diseases. The plant pathologist is, and must be, an opportunist and a generalist because diseases occur depending on a number of contributing factors acting together. For this reason studies have been made and reported, when opportunity arose, over a wide field of subjects. These are reported briefly and pertinent references to the literature given in footnotes.

Peach Defoliation and Bacterium Pruni

One of the most serious diseases of peaches in the "twenties" was defoliation which occurred under a variety of conditions. The common practice in western Kentucky and neighboring states was to grow peaches under a system of clean cultivation and fertilization with nitrate of soda. This system is one that can only result in a continual depletion of soil and in serious erosion. Black spot of fruit and leaf spot both caused by *Bacterium pruni* were present in all orchards and most cases of defoliation were attributed to *B. pruni*. Through observations, a study of the literature, and experiments carried on in the Wood Axton orchard near LaGrange, it was clearly demonstrated that defoliation could be prevented by practices such as manuring, complete fertilization, and cover crops that resulted in soil improvement, and that *B. pruni* did not cause defoliation on well nourished trees. Further, with proper fertilization, *B. pruni* caused only a minor disease of peaches.[1] Another result of the Axton experiments was that Elberta and Hale peaches, manured and allowed to grow up in

[1] Trans. Ill. Hort. Soc. 1928 p 474-488.

sweet clover and weeds, remained firm for a week or more following picking when mature; whereas fruit from well fertilized trees with a rye cover crop disked in ripened and quickly became over ripe following harvest.

A Plum Virus Disease

In the late twenties it was noticed that Japanese plum trees in the station orchard were loosing vigor and in the course of 2 or 3 years became unfruitful, the leaves were small and curled downward, and the older branches gradually died. On some of the more normally shaped leaves ring patterns similar to those of ringspot of tobacco could be found in late spring. Buds were transferred to young peach seedlings with the result that some of the peach leaves the following spring showed typical virus ring patterns. This was apparently the first report of this now well known and widely distributed virus disease of plums and related plants.[2]

Infection of Seed Corn

Following World War I attention was directed by plant pathologists to the group of diseases known as root, stalk, and ear rots of corn and the part that diseased and "disease free" seed corn played. Rag doll testing of ears was recommended as a method of obtaining clean seed. It proved of some value in selecting ears from crib corn but was expensive and not very satisfactory. To determine the true situation as to degree of infection of properly cured and stored seed ears with pathgenic fungi, several hundred ears of corn were studied.[3] Seeds were thoroughly surface sterilized and tested in sterilized rag-dolls, in sterilized sand, in sterile water and after coating with Bordeaux mixture. These studies indicated that practically 100 percent of the kernels carried the fungus *Fusarium moniliforme* Sheldon internally and that the majority of kernels also carried other organisms as *Alternaria* and *Helminthosporium*. Microtome sections of the seed coats showed the fungi to be between the layers of cells of the seed coat. When the seeds were surface sterilized and planted in sterile sand they would germinate normally but in the course of about 10 days the seed coats would become discolored, pink, red, or wine colored or develop streaks of dark green or black. Eventually various fungi would fruit on the discolored areas. Eventually one or another of the fungi (usually *F. moniliforme*) would rot the seminal roots

[2] Ky. Agr. Expt. Sta. Bul. 327, 1932.
[3] Ky. Agr. Expt. Sta. Bul. 226, 1920.

and the plant would die. Under field conditions the fungi caused but little injury.

When seed were collected before maturity, but well enough developed to germinate, it was found that the seed coats were already infested with the several fungi. This suggested that the fungi had entered through the silks following pollination.

As a result of these studies it was recommended that farmers select ears for seed purposes as soon as the husks began to die, dry the ears, and store them in a dry location. In this way ears entirely free from the two ear rots *Diplodia zeae* and *Gibberella saubinetii* could be selected and high germination could be expected without a germination test.

A study of the length of life of seedlings from different ears of corn indicated that seed from some ears developed discolorations early, followed by early injury to the roots; while seed from other ears remained normal in color for a much longer time and the seedlings were much longer lived in the sand box. Also, inbred lines of corn could be classified as to length of life in the sand box. The significance of these results was not entirely clear but they seemed to mean that in some ears the fungi were completely sealed between seed coat layers, whereas in others the sealing was less complete and the fungi could become active more quickly. The studies left no doubt that certain fungi, particularly *F. moniliforme,* are well adapted to live their life in or on the corn plant, enter the seed, and be carried wherever the seed went.

Corn root rot. Further studies on rotting of corn roots by seed borne organisms indicated that they caused little injury except to the temporary roots; even *Gibberella saubinitii* the commonly recognized cause of root rot caused only seedling blight. However when decayed corn roots from a continuous corn plot were added to soil or sand in which fungus free seedlings were grown, a severe root rot developed apparently caused by a species of *Pythium.*[4]

Diseases of Red Clover and Breeding Studies

Red clover is a perennial plant but because of frequent failures agronomists fourty years ago considered the plant to be a biennial. In the early twenties a joint project between agronomy and plant pathology was started to learn more about the causes of clover failure in this area. These studies in one form or another have been continued up to the present time. In the early studies in Kentucky

[4] Jour. Agr. Research 33, No. 5, 1926.

it soon became evident that several diseases, insects, weather, and soil conditions contributed to clover failure. A study of root systems of young seedlings on through the second year indicated that root diseases played a primary part in clover failures.[5] The causes of root decay are still not certain. Nematodes and soil fungi are involved. Blackening of the roots, which is very common, was demonstrated to be caused by the fungus *Sclerotium bataticola* Taub.[6]

The fact that a low percentage of plants survived each sowing, and produced seed, suggested that natural selection in each region where red clovers are grown would rapidly select out material that could survive best in that area. Based on this supposition seed of clovers that had been grown for many years on the same Kentucky farm were collected and tested for survival in comparison with unadapted seed. These tests resulted in the introduction of two varieties, Ky 101 from central Kentucky, and Ky 215 from Western Kentucky. Based on these results a project was started in 1931 to develop a more disease resistant variety by inoculating seedlings with pathogenic organisms and then saving seed from plants that survived 3 or more years. This resulted in the variety Kenland which has proved to be widely adapted in Central U. S.

Mosaic of Red Clover. Bean yellow mosaic has proved to be the most common and injurious virus disease of red clover in this area. It is aphid transmitted and can be tranmitted mechanically. The reactions of numerous plants of red clover to the virus have been studied, with the result that homozygous plants which react with necrotic spots that localize the virus have been isolated. Now the problem is to introduce this dominant factor into a variety such as Kenland that is already adapted to local conditions. This work is underway.[7]

Sclerotinia trifoliorum. As this is an important pathogen of red clover, studies on the life history of the organism and the nature of resistance to it have been made. Ascospores of the fungus are produced in the fall and the disease appears in the spring. Careful observation by Mr. Henson showed that minute spots developed on red clover leaves above apothecia and isolation from these into the winter proved they were caused by ascospore infections. This method of carryover through the winter was a much more realistic way for the fungus to survive than the saprophytic stage previously postulated. The locally adapted varieties of red clover proved much more re-

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[5] Ky. Agr. Expt. Sta. Bul. 269, 1926.
[6] Phytopath. 27: 913-918, 1937.
[7] Phytopath. 49: 541, 1959; 52:729, 1962.

sistant to crown rot than unadapted varieties. It was shown that starch stored in the roots of adapted varieties was used more slowly during the winter and spring than that in unadapted varieties.[8]

Black stem of alfalfa, red clover and sweet clover.—Blackening of the stem of various legumes is common particularly during cool damp springs. While the disease had been observed elsewhere it had been given little attention because it was usually of minor importance. Some seasons alfalfa in Kentucky is severely damaged and stands greatly reduced. A study of the diseased alfalfa, red clover and sweet clover was started in 1930 and reported on in 1933.[9]

The diseases of alfalfa and red clover were found to be caused by distinct species of *Phoma* and that of sweet clover by *Aschochyta lethalis*. Differences were found in resistance of varieties of alfalfa to the disease, and the adapted varieties of red clover were little injured whereas varieties from more northern areas were sometimes severely injured. Any practice, such as winter grazing, which would tend to break down the overwinter shoots of alfalfa on which inoculum is carried would tend to reduce spring infection.

Tobacco Diseases

Because tobacco is such an important cash crop in Kentucky and because so little had ever been done on the diseases of tobacco, a study of tobacco diseases and methods of control was started in 1920 and has continued to the present time. These studies have included virus diseases, root diseases, leaf spot diseases caused by fungi, bacteria, and deficiencies, and miscellaneous other diseases which were studied as opportunities arose. In addition a breeding program, designed to introduce disease resistance from various sources into the types of tobacco commonly grown in Kentucky, has been conducted up to the present time.

Virus diseases. In 1920 the only virus disease of tobacco that was recognized was tobacco mosaic, and not enough was known about it to even recognize the common source of infection. To gain some information about virus diseases records were kept, following setting, of the appearance of virus diseased plants in the plantings on the station farm. It soon became evident that not just one but several previously unrecognized virus diseases were involved. These included tobacco mosaic, ringspot, etch, cucumber mosaic, and vein-

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[8] Ky. Agr. Expt. Sta. Bul. 341, 1933..

[9] Ky. Agr. Expt. Sta. Bul. 339, 1933.

banding, which was later determined to be caused by the potato Y virus. Later streak was recognized as a serious virus disease in some areas of the state. Another virus disease of great theoretical importance is the *Plantago* or ribbon grass virus that occasionally affects tobacco. These virus diseases were studied in some detail by E. M. Johnson, and the report on them used in a thesis presented to the University of Minnesota in partial fulfillment of the requirement for Ph.D. degree.[10]

Etch. This virus disease was first recognized and its symptoms described at the Kentucky Experiment Station. It has since been studied extensively in England and has been found to be a destructive disease of tobacco in Ontario, Canada and in Venezuela, and is a destructive disease of peppers in the southern states. In Kentucky it was recognized as occurring in tobacco near farm garden sites and the same has been found true in Ontario and Venezuela. The virus is found in species of *Physalis* and is apparently transmitted by the potato aphid to tobacco and then spread by the green peach aphid. In Venezuela it appears to be spread by *Aphis cracivora* from pigweed to tobacco. While control measures have not been developed in Ontario, where the disease is destructive, it is satisfactorily controlled in Venezuela by controlling aphids in the whole irrigated area in which tobacco is grown or by keeping the area weed free.

Veinbanding or potato Y virus. This virus disease is of little economic importance in Kentucky although strains of it appear to cause a serious disease of tobacco elsewhere. The virus was found to be spread from potatoes, where it, in combination with the X virus, is the cause of rugose mosaic. In observations covering many years and several countries the disease in tobacco has always been associated with potatoes growing near by. Attempts to isolate it from perennial solanaceous weeds have always proved futile. Inoculations from rugose mosaic potatoes to tobacco by others had produced a disease called spot-necrosis or ringspot, which was thought to be caused by a single virus. Our studies proved it to be caused by a mixture of the veinbanding virus and potato X virus.[11]

Cucumber mosaic. This virus disease is of little importance at present in Kentucky but now that a strain of peach aphid which multiplies on tobacco is common this aphid transmitted virus could become injurious. During the twenties cucumber mosaic was confused with tobacco mosaic even in research studies so that its recognition as dis-

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[10] Ky. Agr. Expt. Sta. Bul. 306, 1930.
[11] Ky. Agr. Expt. Sta. Bul. 309, 1930.

tinct was a contribution. It was also determined that there were more than ten distinct strains of the virus based on symptom expression.

Ringspot. Ringspot was first recognized as a virus disease in 1922 when it was transmitted mechanically at the Kentucky Experiment Station. Since then it has been the subject of extensive studies both here and elsewhere. It was recognized early as a common cause of mosaic in cucurbits and later as the cause of yellows of egg plant in Texas.[12]

Several strains of the virus are known. One strain was found which caused the plant, in the so-called recovered stage, to become yellow throughout. This strain was used in seed transmission studies because, soon after germination, the seedlings carrying the virus bleached out to light yellow and remained yellow throughout life. Seed transmission of 17 percent has been observed. In cool weather field plants affected with a green strain, which no longer show ringspot symptoms, develop chlorosis and slight necrosis along leaf edges. The same type of injury occurs in seedlings carrying the virus of green ringspot. Thus seed transmission of both green and bleaching strains of the virus was demonstrated.[13]

The fact that plants inoculated with the ringspot virus at first develop ringspots, later oak leaf patterns, and finally, when the virus enters the growing point, no longer develop ringspot symptoms but appear almost normal has been interpreted by others to mean that the plant had developed immunity; because when again inoculated no symptoms developed. It was assumed that this immunity was of the same nature as that resulting from vaccination against smallpox. This view was shown to be untenable in a paper which won the King award, Kentucky Academy of Science, 1940.[14] It was pointed out that so-called recovered plants still carried the virus, that at 20°C leaf edge symptoms developed, that seed set was poor, because of a high degree of pollen sterility, and that plants affected by yellow ringspot virus were yellow throughout life and could not be considered to be healthy and immune.

Plantago virus. A virus is common in species of *Plantago,* in Kentucky and in the eastern states, which is readily transmitted to tobacco where it causes a disease similar to tobacco mosaic in some varieties and a severe necrotic disease in other varieties of tobacco. In 1930 a virus was transmitted from a plantago leaf to tobacco which was similar in symptoms to three collections from tobacco. Infected

[12] Phytopath. 41: 209-212, 1951.
[13] Ky. Agr. Expt. Sta. Bul. 327, 1932.
[14] Phytopath. 31: 522-533, 1941.

tobacco was dried and some years later the plantago virus was transmitted from it to tobacco plants, proving that the virus withstands drying the same as tobacco mosaic. In 1941 a Fayette County farmer brought in plants with a severe necrotic disease that proved to be caused by the plantago virus. This led to the recognition of two genetic types of tobacco, one that developed only mottling (nn) and the other which developed severe necrosis (N′N′) when inoculated with the virus. While the disease appears to be of little economic importance the virus is of great interest theoretically as it is probably the virus from which the numerous strains of the tobacco mosaic virus originated.[15]

The rib grass or plantago virus protein contains two amino acids, histidine and methionine, that are not found in several strains of tobacco mosaic virus.[16]

Streak. Streak was first mentioned in the bulletin Tobacco Diseases in Kentucky but the disease there referred to and illustrated now appears to have been caused by the plantago virus.[17] In 1933 the virus disease now recognized as streak was transmitted to a tobacco plant in the greenhouse by grafting.[18]

The disease at that time was rare on the Station Farm and elsewhere in the neighborhood but by 1937 reports of serious outbreaks in northern Kentucky were received and an outbreak in a small planting on the Station Farm was observed where 16.6 percent of the plants were affected. This and outbreaks elsewhere were traced almost certainly to sweet clover plants growing nearby. The virus proved difficult to transmit mechanically at that time so proof of this relationship was not obtained. But in 1945 streak was transferred from 13 of 105 sweet clover plants, collected at random, to tobacco by improved methods of inoculation.[19]

In an unsuccessful attempt to find resistance in tobacco varieties and nicotiana species to streak methods of inoculation were developed that proved highly successful in transmitting the virus.[20]

Tobacco Mosaic. In 1920 when studies on virus diseases at the Kentucky Experiment Station were started very little was known about tobacco mosaic other than that it could be transmitted readily and appeared in the plant bed and field in some mysterious way. When records were kept of the distribution of mosaic affected plants

[15] Phytopath. 33: 210-219, 1943 and Phytopath. 42: 40-42, 1952.
[16] Knight, C. A. J. Biol. Chem. 171: 297, 1947.
[17] Ky. Agr. Expt. Sta. Bul. 328, 1932.
[18] Phytopath. 30: 438-440, 1940.
[19] Phytopath. 40: 516-518, 1950.
[20] Phytopath. 40, 128-133, 1950.

following setting it quickly became evident that infection could be traced to certain people pulling plants, and it was found that these people chewed barn cured tobacco carrying the virus.[21] This discovery led to practical control of the disease. Manufactured tobacco including plugs, granulated smoking tobacco and cigarettes were also found to carry the virus, but were not as great a threat as barn cured leaf.[22]

A study of the effects of a relatively mild strain of mosaic on plants inoculated at setting and topping times on burley tobacco showed a reduction of 43% in yield and 61.7 in value of the crop when inoculated at setting time; and a reduction in value of 25% when inoculated at topping. Later studies elsewhere on other types of tobacco gave similar results.[23]

In some fields of burley and dark tobacco spread of mosaic resulted in one or more leaves on a plant developing large necrotic areas which we called mosaic burn. Attempts to produce burning with mosaic selected at random resulted in failure but when virus was transferred from mosaic burned plants to healthy plants mosaic burn always resulted. These studies proved that there were non-burning and burning strains of the virus.[24]

Further collections of the virus from weeds and tobacco plantings over the state indicated that a careful study of nearly any collection would show differences of one kind or another from other collections.[25] Later collections were made of the virus from tomato plants grown in plastic greenhouses. Fourteen of these collections were tested on Pinto and Golden cluster wax beans, on which tobacco strains produce necrotic spots. Surprisingly none of the fourteen strains, in common with the plantago virus, produced any necrotic spots. This suggests that these strains may be intermediate between the plantago virus and the tobacco strains.[26] A project is underway to determine the amino acid makeup of plantago, the tomato strains, and tobacco strains of the virus to see if any evolutionary trend can be established.

It is commonly recognized that the tobacco mosaic virus is destroyed by heating the virus in water for 10 minutes at 90°C but nothing was known about the effect of dry heat. A test of 3 distinct strains of virus in cured tobacco showed that the virus was destroyed at 80,

[21] Ky. Agr. Expt. Sta. Bul. 280, 1927 and 376, 1937.
[22] Phytopath. 17: 513-522, 1927.
[23] Phytopath. 17: 523-527, 1927.
[24] Ky. Agr. Expt. Sta. Bul. 361, 1935.
[25] Phytopath. 26: 28, 1936.
[26] Pl. Dis. Rept. 46: No. 7, 1962.

100, 120, 140 and 150°C in 50, 10, 1, and .4 hours respectively.[27] This information has been used in helping one of the cigarette manufacturers regulate temperatures in a redryer to destroy the virus in stems (midribs) to be sold to farmers.

The fact that the virus withstands drying from one year to the next raised the question as to how long it would remain active in dry tobacco. The chemistry department had many samples collected over the years and we were lucky enough to obtain samples of burley from the 1882 crop, the same year that tobacco mosaic was first described. These studies showed that the virus was active in samples 24 to 52 years old.[28]

Mosaic control by breeding. Two sources of resistance to tobacco mosaic have been discovered. One of these is a variety of tobacco grown in Colombia, S. A. and the other a necrotic spotting factor present in several wild species of *Nicotiana.* When Ambalema became available in 1934 selections of the most resistant plants were made and crossed with burley tobacco. Resistance was found to be controlled by 2 pairs of recessive factors. Through a backcross program with burley, varieties were developed with a high degree of resistance and good yield and quality. The limiting factor in acceptance was that under good growing conditions two or more leaves would wilt down and scald. So far no acceptable varieties carrying Ambalema resistance have been developed anywhere.

When certain wild species of *Nicotiana* such as *N. glutinosa* are inoculated with the virus a necrotic spot develops at each point of entrance of the virus and usually the virus is confined to these areas. A hybrid of *N. glutinosa* x *N. tabacum* (*N. digluta*), Holmes Samsoun, and a 5th backcross of Ky 16 on *N. digluta* became available in the mid thirties. Using these as a source of the N or resistance factor varieties of burley, one sucker and dark air and fire cured tobaccos were developed that were equal in yield and quality to the standard varieties. At present nearly all tobacco grown in the state is mosaic resistant and mosaic is no longer a problem in Kentucky.[29]

The general use of mosaic resistant burley varieties over the burley area means that manufactured products such as cigarettes, pipe tobacco, and roll-your-own tobaccos no longer carry the virus and consequently are no longer a source of infection of tomato plants in glass and plastic greenhouses. This may account for the fact that collections of mosaic from tomatoes are no longer typical tobacco

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[27] Phytopath. 28: 129-134, 1938.
[28] Ky. Agr. Expt. Sta. Bul. 361, 1935.
[29] Econ. Botany 6: 69-102, 1952.

mosaics, but are probably strains of the virus carried in perennial solanaceous weeds which could differ from the strains that proved successful in tobacco.

Frogeye. Frogeye, caused by a species of *Cercospora,* is a common and sometimes destructive disease of tobacco. Another disease commonly occurs on cured tobacco, from fields heavily infected with frogeye, called greenspot. To determine whether the two spots were caused by the same organisms, isolations were made from both spots and proved identical. Leaves inoculated and held for about 7 days developed greenspot but if held twice that time developed frogeye.[30]

Ordinarily *Cercospora* does not fruit readily in culture so it was necessary to develop a technic whereby large numbers of conidia would be produced that could be used as inoculum. A highly successful method was developed that would produce more than one crop of spores.[31]

If one is to develop control measures for a fungus disease he must know something of the origin of inoculum in an outbreak. Frogeye is rarely seen in tobacco plant beds in Kentucky but is a common plant bed disease in Australia. Its absence in Kentucky plant beds, but its appearance in the field later in the season, suggested that wild hosts might play a part as it had been shown that *Cercospora* of beets could originate from native vegetation. Isolations of *Cercospora* were made from 28 species in 16 families. In culture the isolations were all nearly identical. Inoculations from 16 host species form 11 families produced typical frogeye on tobacco, so it appeared that the tobacco *Cercospora* had a wide host range and was probably synonymous with *C. apii* and many other species.[32]

With this knowledge of the frogeye disease the writer visited many tobacco plantings in Venezuela and observed that some fields were free of frogeye while others had a prominent build-up in the field while the plants were still small. The plant bed season is toward the end of the rainy period and the crop is grown under irrigation during the dry season. When plant beds were placed near the center of large plowed areas, and away from native vegetation, the plants remained free of frogeye. But if the beds were next to native vegetation many of the plants were infected at setting time and these acted as centers of infection in the field.[33]

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[30] Trans. Ky. Acad. Sci. 9:90-92, 1942.
[31] Phytopath. 31:97-98, 1941.
[32] Phytopath. 39:763-770, 1949.
[33] Pl. Dis. Rept. 46 No. 6 1962.

Blue mold. Blue mold or downy mildew of tobacco as it occurs in the U. S. is nearly entirely a plant bed disease. It was introduced into the Georgia-Florida area in 1921, when it was eradicated, and again in 1931; since then it has been a destructive disease each year when temperatures are relatively high in January and February in Georgia. A general outbreak occurred in Tennessee and Kentucky in 1937 then gradually disappeared until in 1944 it was found in only 2 beds in a survey of this area. A general blow-in occurred again in 1945 and again gradually disappeared.

The evidence gathered following these two outbreaks made it clear that the fungus could not survive in areas where spore showers from the south did not occur. While there was carryover in some beds used a second time following a general outbreak carryover was not sufficient year after year to maintain the fungus.

Based on this kind of evidence the writer proposed in the mid-forties that a general program of control be followed, based on discing of beds following settings, and the use of new bed sites.[34] This was particularly important in the Georgia-Florida area where volunteer tobacco plants might appear in the fall, become infected, and be a source of inoculum to new beds. Farther north where volunteer plants could not survive the winter the use of new beds would suffice. The proposal was based on the fact that any farmer, at very little cost, could be certain that blue mold was not carried over on his farm. This proposal left it to the farmer as to whether the fungus was perpetuated on his farm or not.[35]

The proposal was approved by seventeen tobacco pathologists and opposed by two. Signed copies were sent to the Directors of the Georgia and Florida Experiment Stations but the proposal was turned down by the Georgia Station because of the opposition of one man who was sure farmers would not cooperate. If they did not, and the program were only partially effective the responsibility would be where it belongs, rather than on the shoulders of persons who withheld information.[36]

Now that blue mold has become established in Cuba there is a question as to whether destruction of old beds and the use of new beds in Georgia will have any, but a temporary effect, in slowing up the development of an outbreak but they are still practices that should be recommended and followed.

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[34] Phytopath. 34:1012, 1944.
[35] Pl. Dis. Rept. 39:231-232, 1955.
[36] Phytopath. 43:616-618, 1953.

Black shank. Black shank was first recognized in Kentucky in 1935 in Logan and Todd Counties. The fields were sowed to grass and no more trouble was experienced on these farms. It is probable that the disease was present before that time and never built-up because of the common practice of growing only one or two crops on a field and then moving to another field. During the second World War more and more farmers used the same field year after year and black shank gradually became widespread in the state. By 1950 losses were considerable on many farms making it desirable to do something to help farmers prevent further loss.

In 1951 a bulletin was published giving what knowledge we had of the disease and making proposals for the control of the disease on farms where it had already appeared.[37] The program was based largely on planting infested fields to grass and moving to clean fields prepared with clean tools. In 1952 a folder was prepared to be sent to all tobacco growers. This was financed by the Burley Tobacco Auction Warehouse Association and was distributed through the P.M.A. offices to all tobacco growers in the state. In this way the seriousness of the situation and what could be done about it by the individual was brought to the attention of all tobacco growers. In 1951 and 1952 the whole Extension Service directed its efforts toward reducing losses by having farmers move tobacco from infested fields to clean fields. This program paid off and has continued to pay off since, as hundreds of farmers have moved to clean land, following the first appearance of the disease, and have thus prevented any further loss.

The question of how long the fungus remains in the soil following an infected crop was quickly raised. Two observations were made that have since proved correct. One was that where infested land was flooded for a considerable period the fungus was likely to disappear, whereas land above the over-flow area remained infested. The other was that land that contained much limestone or that had been limed, or that had received lime from limestone roads retained the fungus much longer than more acid soils. In addition to these observations fields were selected that had been heavily infested and then left out of tobacco from 1 to 6 years. The fungus was greatly reduced after 3 years and a relation was observed between pH and disappearance of the fungus.[38]

Following the appearance of black shank in the flue cured area and its rapid spread, attempts were made during meetings of the

[37] Ky. Agr. Exp. Sta. Bul. 576, 1951.
[38] Ky. Agr. Exp. Sta. Bul. 592, 1952.

Tobacco Disease Council to trace the first appearance of the fungus in the U. S. to foreign sources and then to follow its distribution in this country. The writer took the position, on several occasions, that the fungus could arise by hybridization from non-pathogenic (to tobacco) strains of *Phytophthora parasitica* and that there may have been independent origins of the tobacco organism in this country and in other areas where tobacco is grown. Some evidence supporting this theory was obtained in a mating study of 35 collections of the fungus from various areas. Two strains were found to be antheridial and 33 oogonial and two groups of oogonial strains could be separated making, in all, at least 4 strains of the organisms extant with possibly distinct origins.[39]

Black root rot. In 1920 when work was started at the Kentucky station on tobacco diseases black root rot, caused by the fungus *Thielaviopsis basicola,* appeared to be the most injurious disease of the crop because many crops failed to grow throughout the season. The disease was apparently the reason for the rotation of many years in grass and only one or two years in tobacco. Enough work had been done on the disease by the U.S.D.A. to indicate that it could be controlled by resistant varieties although all Kentucky varieties at that time were considered highly susceptible.

However in severely affected fields of burley tobacco there were scattered individual plants that grow normally. Sixteen selections had been made from a field of Judy's Pride by the station forman while employed by the U.S.D.A. These were tested in 1920 and 15 of them seemed to have satisfactory resistance. The best of these were subsequently introduced. An interesting feature of this work was the demonstration that Judy's Pride was made up of numerous distinctly different strains as far as plant type was concerned. Farmers who grew the resistant selections commented on the fact that they were uniform and "graded themselves" at stripping time. Other resistant selections were made from Vimont Kelley and from Station stand up variety.[40]

By 1925 it was evident that the resistant varieties were only resistant when planted at a sufficiently high temperature, but showed no resistance in infested plant beds. It was obvious that resistance must be introduced from resistant varieties of a different type.[41]

Ky 16 was introduced in 1936 and Ky 41A shortly after. These varieties, while only moderately resistant, were sufficiently so that

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[39] Phytopath. 44:312-313, 1954.
[40] Ky. Agr. Exp. Sta. Circ. 28:1922.
[41] Ky. Agr. Exp. Sta. Bul. 262, 1925.

they were successful in infested plant beds and fields in Kentucky but were not entirely successful when grown in Ontario, Canada. Later varieties such as Ky 26 and Ky 57 were developed that had a still higher degree of resistance.[42]

Studies made at Harrow, Ontario have demonstrated that decomposing organic matter develops materials that are toxic to newly set tobacco plants and that these toxic materials breakdown resistance to *Thielaviopsis basicola*. It is the writers opinion that what we have considered to be loss of resistance of such varieties as Ky 16 and Bur. 21 during the past decade is, in all probability, the direct effect of toxicity and of poor aeration resulting from growing tobacco year after year on the same plot and turning under heavy cover crops without sufficient time to decompose.

T. basicola is a variable organism in culture. Different isolates are likely to differ in color, size and shape of chlamydospores, in the proportion of chlamydospores to endoconidia with some cultures unable to produce endoconidia. Single spore cultures from a culture may differ and single spore cultures from a single spore culture may be different. Color varieties from a single spore culture are common. The genetics of the organism have not been studied.[43]

Recently soil collections have been made from uncultivated soils in the mountains and from other areas, and tobacco grown in them. Highly susceptible tobacco has been only slightly affected although *T. basicola* was found fruiting on the roots. The results of these tests suggest that strains of the fungus with little pathogenicity to tobacco exist on the roots of native vegetation. This phase is being studied in greater detail.

Angular leafspot and wildfire. These two bacterial diseases of tobacco have been the subject of constant observation and research since 1920 when both diseases were first recognized in Kentucky. Both had been described elsewhere shortly before that time. At that time practically nothing was known about either disease except that they were caused by bacteria that gave certain reactions on artificial media.

A study of the organisms on artificial media indicated that they were identical in appearance and could not be separated in culture. Both were short lived on potato-dextrose-agar because the medium rapidly became acid, but on beef broth both organisms were long lived. A detailed study of freshly isolated cultures indicated that they were made up of several strains that differed in colony characters,

[42] Econ. Bot. 6:69-102, 1952.
[43] Phytopath. 25:1011-1018, 1935.

from watery to rough colonies, that maintained their individual characters through at least 10 passages through tobacco leaves.

When single colony cultures of either organisms were made and stored in distilled water changes occurred in storage in some cultures, wildfire producing angular leafspot, and vice-versa. When single cell cultures of both organisms were stored in beef broth the wildfire cultures sometimes produced angular leafspot, but the angular leafspot cultures remained constant. In nature there has apparently been a shift from one organism to the other for some unknown reason. From 1920 to about 1934 angular leafspot could be found in nearly every bed, while wildfire was rare. Later wildfire became very common and angular leafspot was rare.

In early studies elsewhere seed contamination was considered the source of infection in beds but we were never able to confirm it. Studies of carryover in soil were therefore started and it was demonstrated that both organisms survived the winter in soil provided there were living roots present. An examination of roots under the microscope revealed bacterial colonies which, when used as inoculum, produced one or the other disease. Both organisms could also be isolated from roots in old bluegrass sods. These results gave a sound basis for developing control measures.

Some confusion existed as to just how bacteria entered uninjured leaves. Tests with water soaked leaves demonstrated that motile and nonmotile bacteria, India ink particles, tobacco mosaic virus and chemicals all entered water soaked portions of leaves immediately on being poured over the surface. It was demonstrated that both internal water soaking and soaking by wind blown rain could play a part in natural outbreak of the diseases.[44] Watersoaking from external sources was clearly demonstrated to be dependent on stomatal opening which usually occured only during the day. *Xanthomonas vesicatoria,* a bacterial organism causing fruit spots on tomato and leafspot on peppers was also found to overwinter on the roots of wheat.[45]

Black-leg. This bacterial disease was recognized and described as a previously unknown plant bed disease.[46] It is caused by a common soft rot organism *Bacillus aroideae* which also causes hollow stalk of maturing tobacco. Another bacterial disease that has been under observation for many years is bacterial black stalk, a disease that attacks maturing tobacco and sometimes is very destructive to

[44] Ky. Agr. Exp. Sta. Bul. 454, 1943.
[45] Phytopath. 34:998-999, 1944.
[46] Phytopath. 21:973-978, 1931.

small groups of plants. Very little has been learned about this disease.

Breeding Tobacco for Disease Control[47]

The ideal method of disease prevention is through the development of resistant varieties, provided the pathogen is not adapting itself to life on the new varieties as rapidly as they are produced. Breeding for resistance to black root-rot has already been mentioned. It has been highly successful in reducing losses to burley tobacco but it has been difficult to develop satisfactory resistant varieties of the dark tobaccos.

Following the introduction of satisfactory black rot resistant burley varieties the next problem was to develop satisfactory varieties combining resistances to fusarium wilt, mosaic, the leafspot diseases, wildfire and angular leafspot, and black shank.

In the early fourties the mosaic resistance factor from *N. glutinosa* was transferred to all of the burley breeding lines and all varieties subsequently introduced carried mosaic resistance. Ky 35 was the first burley variety introduced carrying resistance to three diseases, black root rot, mosaic, and fusarium wilt.

Several wild species of *Nicotiana* were found to be resistant to wildfire and presumably to the similar organism causing angular leafspot. The resistance factor was transferred from *N. longiflora* to tobacco both at the U.S.D.A. and at the Kentucky Experiment Station. The U.S.D.A. transfer proved to be more stable and is now being used in our breeding program. At present a considerable number of breeding lines of burley carrying high resistance to mosaic, black root rot, fusarium wilt and wildfire are being tested for acceptability by manufacturers. One of these, Ky 12, has been introduced for use particularly to control fusarium wilt.

Resistance to mosaic appears to be entirely satisfactory; and so far there is no evidence of breakdown of resistance to the fusarium wilt organism. Black root rot resistance, while highly satisfactory, is variable depending to some extent on the degree of organic matter toxicity from decaying cover crops; the greater the toxicity the lower the resistance. Wildfire resistance is generally satisfactory both in the plant bed and field but strains of the organism have been found that are virulent and injure the resistant varieties as much as susceptibles. Many fields of resistant tobacco have been seen that appear susceptible to the angular leaf spot organism.

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[47] Econ. Bot. 6:69-102, 1952.

N. longiflora appeared in preliminary tests to be immune to the black shank fungus, and a breeding program was commenced to transfer this factor to tobacco. At present we have one burley variety, L8, that appears to have a pair of *longiflora* chromosomes substituted for a *tabacum* pair and is resistant. It is of little value except in the production of F_1 hybrids with other burley varieties. These proved immune to black shank on most fields, but on one a strain was present that destroyed the resistant plants, raising a question as to the permanent value of this type of resistance. L8 is now being used in the production of an F_1 hybrid with Burley 37 (a resistant variety with *tabacum* resistance). It is hoped that the combined resistances will make a virtually immune variety that may be used in eradicating the fungus from a farm.

Root knot resistance. Root knot nematodes are largely confined to farm gardens and are rarely found in field grown tobacco but they are a potential menace to the crop. Using a flue cured variety resistant to the common root knot nematode of tobacco, varieties of burley have been developed resistant to mosaic, black root rot and root knot nematodes.

Related Breeding Studies

Low nicotine Burley and flue cured tobacco. About 1932 low nicotine cigar tobaccos were received from Germany. As nicotine, at that time, was considered injurious to health of some people it was decided to develop low nicotine burley tobacco, and hybrids with the cigar tobacco were made. The low nicotine cigar tobaccos were low in nicotine but high in nornicotine. Selections were made for low total alkaloids with the result that finally burley varieties were developed with a total alkaloid content of about .2%.[48] The John Alden Tobacco Company was organized to manufacture low nicotine cigarettes, cigars and pipe tobacco. The products were accepted by a small percentage of smokers many of whom claimed benefits to health from the change. The project was not profitable and was abandoned.

Inherited abnormalities. Tobacco appears to be the result of a cross between two wild species of *Nicotiana* after which the chromosome number of each set of chromosomes was doubled resulting in a fertile hybrid. This means that tobacco carries duplicate genes for everything necessary to carry on life. Consequently mutations can take place in one subgenome without being apparent in the progeny so long as the similar gene in the other subgenome is normal. When

[48] Jour. Agr. Research 78:171-181, 1949.

a similar mutation takes place in the other subgenome then a portion of the seedlings will be abnormal. Three recessive mutations have been studied that seem to fit into this pattern; they are Yellow Crittenden, Virescent and Genetic Veinbanding.[49]

Another recessive variegation named Silver may be in the same category but it is not certain.[50] Two dominant mutations, Variegation D and Variegation I have also been described. Both are evidently transmitted through chromosomes but Variegation I appears to result from an irregularity in cell division in which one chromosome forms a bridge.[51]

Calcium deficiency. Leaf edge necrosis of sucker leaves and necrosis of calyx lobes has occurred in burley tobacco since the introduction of mosaic resistant varieties. Genetic studies demonstrated that this condition is associated in some way with the H chromosomes which carries the mosaic resistance factor, but it was also demonstrated that the mosaic resistant factor was not the direct cause of calcium deficiency symptoms, and that some mosaic resistant varieties did not show starvation symptoms.[52]

Nicotine conversion: All commercial tobaccos contain nicotine and either a trace or an appreciable amount of nornicotine. Studies of individual plants in a variety showed that certain ones carried little nornicotine while others contained a relatively large amount. Genetic studies showed that the high nornicotine plants carried a dominant factor for conversion of nicotine to nornicotine during curing, while in the low nornicotine plants this factor was absent. Manufacturers reported that nornicotine gave an unpleasant aroma to the smoke and so a method was available for quickly eliminating nearly all nornicotine from cigarette tobaccos.[53]

Diseases Caused by Nematodes

Root diseases, in which many of the small feeding roots are destroyed, are common to our crop plants and even to weeds. Diagnosis is often difficult because of the multiplicity of organisms that may be concerned. Brown root rot has been recognized as a distinct disease for many years but its cause was not understood. A study of brown root rot was started in the early twenties but without results. In 1946 a study was made of root lesion nematodes in tobacco

[49] Tobacco Science 1:91-92 and 175-176, 1957; 2:20-22, 1958.
[50] Tobacco Science 4:172-175, 1960.
[51] Tobacco Science 2:77-79, 1958 and 4:176-178.
[52] Crop Science 3:265-266. 1963.
[53] Science 121: 343-344, 1955.

plants showing typical symptoms of brown root rot. Evidence was obtained indicating that the disease in Kentucky, and probably also in Conecticut, Wisconsin and Ontario was, in part at least, caused by root lesion nematodes.[54] It now appears certain that a part of the brown root rot complex is brought about by cover crop and manure toxicity, as demonstrated by the recent studies by Patrick in Ontario.

Over a period of years alfalfa had been sown in wheat in the spring in a rotation series on the Station Farm, but always failed. Farmers have usually had the same result. Reseeding in August following a period of fallow always resulted in a good stand. A study of the cause demonstrated that failure was caused by heavy infestation of seedling alfalfa roots by root lesion or meadow nematodes moving from dying wheat roots to the tender alfalfa roots. A fallow period during the summer greatly reduced the nematode population and alfalfa seedlings survived.[55]

Other studies of the effect of various nematodes on the growth and development of roots and tops of alfalfa and red clover plants growing in the greenhouse have been made.[56]

Studies on the Physiology of Disease and Disease Resistance

Much of the work done in the past has been with relatively simple equipment and has been directed toward practical ends; a sufficient knowledge of the disease to arrive at sound recommendations for control, or control through disease resistance. There is much to be learned about the physiology of disease caused by fungi, bacteria and other agents. For these studies modern equipment will be necessary together with personnel competent to use the equipment. The Department of Plant Pathology has recently acquired the following equipment: Warburg constant volumn respirometer, Zeiss PMQ II spectrophotometer, Spinco model L ultracentrifuge, Technicon automatic amino acid analyzer, paper and thin layer chromatography equipment, and paper and gel electrophoresis equipment.

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[54] Phytopath. 37:838-841, 1947.
[55] Phytopath. 44:542-545, 1954.
[56] Phytopath. 48:525-530, 1958; 49:357-359, 1959; 54:1003-1005, 1963.

THE ADVANCE OF GEOLOGY IN KENTUCKY DURING ONE HUNDRED AND THIRTY-FOUR YEARS (1784-1918)

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A handful of scattered notes and references comprise the entire assemblage of topographical, geological and mineralogical observations on Kentucky that found its way onto the printed page prior to the year 1838. In 1784, John Filson's now very rare book on *The Discovery, Settlement and Present State of Kentucke* appeared first in Wilmington and Philadelphia, later in Lexington and Louisville. In it are to be found brief descriptions of the cliffs of the Kentucky River, the salt springs of Drennon and Big Bone and other natural curiosities including citations of the occurrence of iron and lead ores and crude oil. In Gilbert Imlay's: *A Topographical Description of the Western Territory of North America,* the first edition of which was printed and issued in London, England, in 1792, there are a number of very clear and well written passages on some aspects of regional topography in Kentucky, particularly a paragraph or two on the Barrens of southwestern Kentucky and the sinks and caves that mark this remarkable area. Similarly, in the writings of Thomas Cooper, Dublin, 1794; James Meace, Philadelphia, 1807; William McClure, Philadelphia, 1809; Jeremiah Van Rensselaer, New York, 1823; John J. Audubon, Edinburgh, 1831 and John Lock,[1] Columbus, 1838, there occur passages that range from simply a reference of one or two lines to adequate and detailed description of some particular geological phenomena, as for instance Audubon's, *An Earthquake in Kentucky,* which is the best in early geo-seismic literature in America.

Preliminary Survey

The year 1838 is one that is of outstanding importance in the field of Kentucky geology as it marks the beginning of comprehensive professional investigations in this State. A very gradual awakening in various parts of the Commonwealth during the mid-1830's to the importance of a careful and comprehensive examination of the geology and mineral resources of Kentucky resulted in a number of petitions signed by considerable numbers of taxpayers being pre-

[1] For these and a few other early titles pertaining to Kentucky see: *Geologic Literature on North America: 1785-1918.* 1167 pp. By John M. Nickles, Bull. 746, U. S. Geol. Survey. Washington, D. C., 1923.

sented to the General Assembly during the session of 1838. As a result of this, a Resolution was passed directing and authorizing the Governor to select and appoint a competent person to visit the mineral regions of the State and make a report on the same together with recommendations as to the establishment of geological survey of Kentucky. Shortly thereafter Governor James Clark appointed Dr. William Williams Mather, then the State Geologist of Ohio. He had been (1836 and 1837) the Geologist of the first geological district of New York. Dr. Mather came to Kentucky forthwith, traversed representative parts of the eastern, western and central divisions of the State, wrote and submitted to the Governor ere the year was out an outline of his work entitled: *Report on the Geological Reconnaissance of Kentucky Made in 1838.*[2] Comprehensively and well done 40 pages, it was advanced to the House of Representatives as an executive paper and published by that body in its Journal of 1839. Without question the first and the most important record of the geology of Kentucky up to its time, and for fifteen years thereafter, it may properly be called the first chapter in the slowly unfolding tome embracing the sciences of geology, mineralogy and paleontology of Kentucky.

After the Mather survey there was a period lasting a little more than a decade and a half, of notable and inexcusable quescence in the field of official investigative geology in Kentucky. During this time great names in mid-nineteenth century geology and some not so great, dot the pages of the Kentucky book—James Hall and Timothy A. Conrad from New York, Byrem Lawrence and Jules Marcow from Massachusetts, David Dale Owen of Indiana, Joseph G. Norwood of Missouri; David Christy of Ohio; Benjamin Silliman of Connecticut and Sir Charles Lyell of England, and not a few others, each came and went and produced a book, a pamphlet, a paper or a map in the composite of which Kentucky appeared again and again by way of reference, large or small, accurate or otherwise, but the summation of all these citations and representations so far as the advancement of the *geology* of the Commonwealth was concerned was pitifully small and essentially of no major importance. Growing impatience in the minds of many forward looking citizens with the *laissez faire* attitude of a succession of governors in the organization of investigations of the *Geology and Mineral Resources of Kentucky*—the exact title used by this writer for a book some 80 years later—brought on again the presentation of a number of memorials

[2] *Geological Research in Kentucky.* 211 pp. Maps, Illust. By Willard Rouse Jillson. Vol. 15, Ky. Geol. Survey, Ser. VI. Frankfort, Ky. 1923. Pages 1-6.

of associations from various parts of the State to the Legislature of 1853, with the summary result that a bill was passed and approved by Governor L. W. Powell providing for a thorough geological and mineralogical survey of Kentucky. The State's Chief Executive, under the terms of the Act, was required to appoint a State Geologist to organize and effectuate under the statute.

First Survey

Governor Powell selected Dr. David Dale Owen of New Harmony, Indiana. Owen, born in the British Isles, the son of a great mill owner, philanthropist and social reformer in Scotland, was well chosen for the scientific and administrative work that lay ahead of him. He accepted and threw himself with great vigor into the organization and activation of the "First" Geological Survey of Kentucky. Having already completed a geological survey of Indiana for that state, and broad exploratory geological surveys of Iowa, Wisconsin and Illinois for the 26th and 28th Congresses and the United States Treasury Department as well as a number of other geological traversements of other western and Mississippi Valley States, he was in an excellent position to undertake the work in Kentucky. This First Geological Survey of Kentucky began with the opening of the field season of 1854 and was continued as weather would permit through 1855, 1856, 1857 and 1858—until the sudden and shocking death of Dr. Owen on November 13, 1860, at the mid-maturity age of 53 years.

In the course of his five years at the head of the Kentucky Survey, Dr. Owen with a carefully selected corps of well trained and competent men, produced four large volumes (7″ x 10″) totalling 2,012 pages, beautifully illustrated by his own artistic pen, covering in reconnaissance every county and all of the State of Kentucky. Though obviously and necessarily a pioneering, scientific work, it embraced a thorough chemical investigation of the soils coupled with a regional discourse and portrayal of the areal, stratigraphic and structural geology of the Commonwealth. A dependable work, it is now and will always be regarded as an impressive spread of reconnaissance geology of the first order. The detailed stratigraphic sections Dr. Owen produced for the Coal Measures of Eastern and Western Kentucky were so accurately measured and drafted that during the 110 years that has elapsed since this phase of the first Survey's work was completed, no important correction or revision of these guide-posts of late Paleozoic sedimentation has ever been made. Dr. Owen's achievement in this as well as various other phases of his geological work in Kentucky thus assumes on its own record and character, as the years pass, a heighening significane and bids fair to be widely recognized during the present century and for all time as a classic example of a pioneering geological survey with broadly approved dimensions of the first order of magnitude.

Second Survey

Closely following the death of Dr. Owen and the abrupt termination of the statewide geological and mineralogical work that he headed, the devastating effects of the Civil War, which had been brewing for a decade or more, overspread the land. Any thought in legislative halls or elsewhere of continuing official geological work in Kentucky, a pivotal border state, across which armies, large and small, of both North and South commands moved at will, died aborning. Again a fifteen year "standby" period elapsed and nothing in the way of new work was added to the record except Professor Nelson Sayler's *Geological Map of Kentucky*. The field work upon which this very excellent piece of cartographic geology was based, was executed—no one will ever explain how—during the precise period of bloody internecine strife marked by the Civil War, for the map[3] was printed and issued in Cincinnati in 1865. Done at the scale of 1 inch = 16 miles and printed in colors to show with clarity the areal spread and pattern of the exposed formations, without State aid for the costs of the field work or the printing, it is truly a very remarkable scientific achievement, duplication or improvement of which was not to be attempted again by anyone in Kentucky until after the passage of a full decade.

During the reconstruction period, the practical value and worth of State geological surveys in developing mineral resources of various types, came to the attention of the Legislature in 1872 and again in 1873 at which time an Act was passed and approved by Governor P. H. Leslie, establishing a new or as it came later to be called, the "second" Geological Survey of Kentucky. By the authority of this Act, Governor Leslie appointed forthwith, Professor Nathaniel Southgate Shaler, a native of Newport, Kentucky, and at that time Professor of Paleontology in the Lawrence Scientific School of Harvard University, Director and State Geologist. Dr. Shaler accepted and pro-

[3] Described in detail in *The Geological Map of Kentucky*, a 12 page pamphlet by Willard Rouse Jillson, Frankfort, 1945. Page 7. The author has a photostat copy of the Sayler *Geological Map of Kentucky* of 1865 in his cartographic files. This map is a very *rare* item. Oddly, an original copy of this unique map by Professor Sayler is not known to be in Kentucky today.

ceeded to organize and effectuate the second State Survey. He chose Dr. Robert Peter, a staff member of the old Owen Survey, as State Chemist, Dr. A. R. Crandall as geological assistant, J. H. Talbot as chemical assistant, P. N. Moore a geological aid and J. A. Monroe, C. W. Beckham and C. Shenk as field assistants. Later he employed John R. Proctor as office assistant, and thereby hangs a tale!

The Shaler Survey endured for seven years, until the mid-Spring of 1880. In course, widely diversified studies were made by various geologists, most of whom, like C. J. Norwood, W. M. Linney, W. B. Caldwell, and J. B. Hoeing were employed with others necessary to complete parties, for late Spring, Summer and Fall field work. As a result of these investigations six volumes (7″ x 10″) totalling 2,886 pages were issued and distributed. Under the administration of Professor Shaler, Kentucky may be said to have enjoyed its *first systematic and diversified* (specialized assignments) geological survey. This type of field investigation, of course, was not possible for either the Mather or the Owen Surveys as their work was of necessity of a preliminary and pioneering character—since no broad spread of basic work in the field had preceeded them. In addition to a lengthy list of strictly professional reports and memoirs, Dr. Shaler, himself, for he was an indefatigable worker in both the field and the office, designed and issued in 1875 a *Preliminary [Geological] Map [of Kentucky] Compiled from Various Surveys.*[4] Done in black and white, with varied hatching to show the areal geology, it was the *first* official geological map of Kentucky and was, of course, a great improvement upon the 1865 map of Professor Sayler.

Dr. Shaler as has been noted was an important member of the professorial staff of the Lawrence Scientific School at Harvard University at the time of his appointment to head the second Geological Survey of Kentucky. As such he had also the fixed obligation of teaching duties at Cambridge during the college year and could, of course, only be in Kentucky during the Summer vacation, that is, from about June 15th to September 14th of each year. This was known to Governor Leslie when he appointed him to the head of the Geological Survey of Kentucky, it being his thought that Shaler's professional ability and distinction in the twin fields of geology and paleonthology were amply compensatory for his absence during the late Fall, Winter and early Spring when, as was well known, it was impossible to do extended field work in Kentucky anyway. But there

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[4] The author has a copy of this map of 1875 in his cartographic files as of May 1, 1964. It is a rare item, very seldom seen.

were others who felt differently about the matter. One of these was John R. Procter, Shaler's office assistant. He was neither a college graduate nor a professional geologist, but he was of the opinion, after working with his superior a number of years and attending one summer session of Shaler's Summer School at Cumberland Gap, that he could, by staying in Kentucky the year round, produce a better Geological Survey than Dr. Shaler could and had, with his long absences at Harvard.

John R. Procter was a capable man of no very limited abilities in the fields of administration and persuasion. Others in Frankfort soon came to feel about Shaler's absence while State Geologist much the same as Procter did. Some of the men in Frankfort who shared Procter views were in the Legislature of 1880 and one of more elevated political estate than the others occupied the Governor's chair. In course a bill was introduced in the Legislature requiring the State Geologist and Director of the Kentucky Geological Survey to reside at all times, when not actively engaged in field work in the State, at the Capitol, Frankfort. Supported by a number of convivial spirits in the Legislature and the sanction of the Governor the bill passed with little or no real opposition. An utterly impossible immigration rider was attached to the bill which made the Act seem very plausible to those who did not understand that chamber of commerce activities in the field of European immigration into Kentucky could not very well be mixed with the minerals and fossils of bed rock geology. When Dr. Shaler heard of the Act recently past requiring the State Geologist to live in Frankfort he promptly resigned. It was the month of April, 1880.

Governor Luke P. Blackburn immediately appointed John R. Procter Director of the Kentucky Geological Survey and Bureau of Immigration. Unable to do original, *first* class geological field work himself and equally incapable of checking, correcting and revising the reports of others, Mr. Procter selected a staff of assistants, the outstanding members of which were: Dr. Robert Peter, chemist, Dr. A. R. Crandall, Professor William M. Linney, Dr. R. H. Loughridge, Professor Edward Orton, Mr. James M. Hodge and Mr. George M. Sullivan as Assistant Geologists. Mr. Joseph B. Hoeing, who had been in the Shaler Survey, was employed as Cartographer and Engineer. During his term of office—1880 to 1892—Mr. Procter reassembled and published from previously prepared plates of type-pages, five volumes of the work originally done and previously published by the Shaler Survey. He issued new and for the first time four volumes, the work of Orton, Peter, Loughridge and Linney—a total of nine volumes encompassing 3,020 pages. Each of the four new volumes, the writer has been advised by a contemporary and competent critic, then on the Survey Staff,[5] were published by the Procter Survey without professional review and revision except by their several separate authors. This method of editing scientific MSS for publication, of course, relieved the office of the Survey and the Director personally of much slavish labor, but visibly might not have found unqualified approval or very general practice in other State Geological Surveys, at that time, or at any time thereafter including the present. This type of management and control of its publications by the Procter Survey eventually spread to other divisions of the work particularly its financial and employment brackets. An adverse report by the State Inspector and Examiner brought a sharp reply from the Director and a critical and decisive resolution and enactment in the State Legislature, the last of which brought the (Procter) Survey suddenly to the end of the road in 1893.[6] Now that "three score and ten years" have passed since the events noted here transpired, it may in truth be said that the new work in oil and gas by Dr. Orton, on the Jackson Purchase by Dr. Loughridge and on the several counties by Professor Linney and Mr. Hoeing were reasonably good and quite abreast of their time, and the old work of the (Shaler) Survey—five volumes of about 1,600 pages, while dependable were unquestionably tending to be obsolete when reprinted. Their publication cost, clerical handling and transportation expense was an obvious and flagrant waste of State money.

Individual Work

Occasionally prior to and during the Owen Survey, as in the instances of Dr. B. F. Shumard and L. P. Yandall of Missouri, and Joseph P. Lesley of Pennsylvania; previously as in the case of James M. Safford of Tennessee and subsequently as witness Joseph P. Lesley again, W. E. Logan of Montreal and James Hall of New York,[7] Sidney S. Lyon and S. A. Casseday of Indiana and numerous others, individuals touched, frequently very effectively and sometimes with remarkable accuracy, certain phases of Kentucky geology and paleontology which they chanced to observe, usually quite accidentally. These independent papers have oftimes embraced the description of

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[5] Comment to the writer in the early 1920's by Professor C. J. Norwood, formerly State Geologist of Kentucky, and at the time of comment, Dean of Mining Engineering at the University of Kentucky.

[6] Bull. No. 109, U. S. Nat. Museum. G. P. Merrill, pp. 122-123.

[7] *Bibliography of Kentucky Geodogy* by Willard Rouse Jillson, Chap. IV, Vol. 15, Ser. VI, Ky. Geol. Surv., 1923. P. 120.

a new fossil or an important metaliferous ore, the comparison of near and distant stratigraphic sections, the citation of strike and dip of certain beds near springs of petroleum or perhaps of an oddity of creek or river drainage. Many of such papers and pamphlets appearing in journals or as reprints, of course, have been well done and so possess good and permanent value. Very frequently at a later day, sometimes 25 or 50 years, afterwards, a two page description of a little geological or palentological trifle, noted previously by someone in the course of more extended field work, has very appropriately fitted into and aided the identification of some series of beds or clarified the interpretation of a partly covered oil and gas structure. This sort of "free lance" geology continued on through the years of official inactivity previous to 1873, then through the Shaler and the Procter Surveys and on through the long decade of State disinterest that followed the closure of the second Geological Survey of Kentucky in the Spring of 1893.

Third Survey

As the last years in the Nineteenth Century arrived and opened up the prospect of increased mineral development in Kentucky, it gradually became common knowledge as the result of inquiry that practically all of the old reports touching on coal, oil and gas of the earlier State Survey were exhausted in edition and gone. A year or two after 1900, as the demand for Kentucky coal, oil and gas became greater and the lack of competent State geological reports came to be widely recognized as a barrier to industrial development, a number of proposals were advanced to rectify the situation. Finally a bill was introduced in the General Assembly of 1904 "providing for and authorizing the curator of the affairs and effects of the old, second Geological Survey to resume the geological, topographical and agricultural survey of the State of Kentucky "and appropriating funds therefor. This bill passed both houses of the Legislature unanimously and was shortly thereafter signed and approved by Governor J. C. W. Beckham. Under the articles of this Act, Professor Charles J. Norwood, a teacher of mining engineering at the University of Kentucky, without actual appointment or additional salary, became the State Geologist and Director of the new, the "Third" Kentucky Geological Survey.

The Act under which he held office directed Professor Norwood and his assistants to report upon the economic geology of the State. Accordingly a group of capable geologists were selected and assigned as follows. Joseph B. Hoeing, oil and gas; A. M. Miller, lead and zinc; A. M. Peter, chemical analyses; A. R. Crandall, Big Sandy coals; James H. Gardner, Kentucky clays and J. Julius Fohs, fluorspar and barite. All of these assignments were executed with care, precision and credit to all concerned. Manuscripts, frequently illustrated with maps and photographs were written, printed and issued as separate reports of the Kentucky Geological Survey, Series III. Altogether some twenty odd reports and four Reports of Progress were completed and placed in active circulation.

To the credit of Professor Norwood and the men who made up his staff including very able geologists like Professor August F. Foerste, Dr. William C. Morse and Dr. L. C. Glenn, and others not mentioned above, the Third Survey which lasted longer than the Mather, the Owen or the Shaler Surveys but was four years shorter than the Procter Survey, did a very broad and excellent spread of Economic Geology and General Geological work. Unfortunately, a number of important manuscripts on the geology of certain economically important districts or counties, by some directive drag which Professor Norwood disclaimed, or financial impasse, which is altogether more likely, were not published at the time as they should have been. Professor Norwood openly blamed the State Printer. The public controversy which followed injured both Professor Norwood and the Third Geological Survey as it provided the political material then sought by certain interests with which to remove Professor Norwood from the Directorship and to abolish at the same time the Kentucky Survey he had so capably headed for eight years.

Fourth Survey

With the meeting of the General Assembly of Kentucky early in January of the year 1912, it soon became apparent that the Norwood (Third) Survey was doomed. Native Kentuckians in Eastern Kentucky interested in the rapid development of coal, oil and gas as well as other earth minerals such as sewer pipe and firebrick clays, rode range at will on both houses of the Legislature, alleging that the Kentucky Geological Survey had fallen into slothful inactivity and accordingly demanded that it be reorganized from cellar to garret. The leaders of this movement were supporters of old Governor James B. McCreary, and accordingly had unlimited access to his office and soon converted him to their way of thinking. A bill was introduced in the House which abolished the Third Survey, removed its office, properties and effects, with exception of the State Museum, from Lexington to Frankfort, and provided that the Governor appoint with the advice and consent of the Senate a competent person as State Geologist who had a thorough scientific and practical knowledge of geology, mineralogy, hydrology, chemistry and allied subjects, and one who shall not be connected with any college, and shall devote his entire time to the geological surveys. A Board of control consisting of five members were also provided for in the Act. It found its way easily through the House, passed the Senate unanimously March 2nd and was readily approved with his signature by Governor McCreary, March 7, 1912.

In accordance with the new statute, when it became effective July 1, Governor James B. McCreary appointed Joseph Bernard Hoeing, a native of Lexington, Kentucky, where he was born March 27, 1855, State Geologist and placed him in charge of the Fourth Kentucky Geological Survey and all of its activities, personnel and properties. Mr. Hoeing, a graduate of Rensselaer Polytechnic Institute of Troy, New York, in the class of 1876 with the C. E. degree had been, it will be remembered, an employe of the Shaler, Procter and Norwood Surveys, rising with competence from assistant to cartographer, to engineer and finally to assistant geologist on the Third Survey under Professor C. J. Norwood. Very able in his chosen professional field of engineering and well experienced in the activities of the Kentucky Geological Survey from personal contact over a period of about 25 years, Hoeing proceeded to revise and publish the manuscripts he inherited from the Norwood Survey, while building up a staff of very capable geologists including A. F. Crider, A. M. Miller, A. F. Foerste, F. J. Fohs, J. M. Hodge, Charles Butts, W. C. Phalen, Wallace Lee, E. O. Ulrich and others. During the six years of his incumbency Mr. Hoeing issued five volumes, divided into 13 parts, of page size 7″ x 10″, bound in dark red cloth. Taken as a whole this unit of work was creditable to both authors of this survey. Mr. Hoeing finally retired from the office of State Geologist when the statute governing the Fourth Kentucky Geological Survey was altered and debased by the State Legislature of 1918, which was pledged to a general policy of retrenchment and reform. Part II of Volume V of the fourth survey was printed and issued in 1919 after Mr. Hoeing had vacated his office. During his active years as State Geologist, Mr. Hoeing's published reports of the Fourth Survey (1912-1918) totalled 4,280 pages of very creditable reports on the geology of Kentucky.

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PHYSICAL, CHEMICAL, AND BIOLOGICAL DATA ILLUSTRATING A STREAM CLASSIFICATION SYSTEM

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Introduction

Kuehne (1962) found that fish in Buckhorn Creek of eastern Kentucky could be used to illustrate the Horton (1945) system of stream classification. In this classification all headwater streams are classified as order I. The junction of two or more order I streams forms an order II stream. The junction of two or more order II streams forms an order III stream. A stream remains at a given order of magnitude until it joins a stream of equal magnitude. At this point the stream order is raised to that of the next highest magnitude. The entrance of streams of lower order into those of higher order has no effect on the magnitude of the higher order stream.

During the spring of 1963 a study of the Hickman Creek drainage system in central Kentucky was made for physical, chemical, and biological data that might be used to illustrate the Horton system of stream classification. It was also felt that the data might show the effects of pollution upon the normal physical, chemical, and biological characteristics of this classification system. In this paper the aquatic insects, free diving helminths, some crustaceans, and selected physical and chemical data are discussed with respect to the Horton system, sewage pollution, and possible interrelationships.

The Hickman Creek drainage basin is approximately 97.2 square miles in area. Length from source to mouth is 37 miles. It is a fourth order stream as determined from U.S. Geological Survey topographic maps of 1:24,000 scale. The average gradient for each order, average length for each order, total length and total number of streams for each order are shown in Table 1. The drainage density (area/length of streams) is 2.06. The stream frequency (area/number of streams) is 2.07. These latter values are considered about normal for most drainage systems.

Materials and Methods

Fourteen widely selected stations were sampled once each month for four months during the spring of 1963. These were arranged so that at least three stations were sampled each month on the same

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Table 1. Hickman Creek Drainage System—Physiographic Data

Order	Number of streams	Total length	Average length	Gradient (ft./mile)
4	1	36.1	36.1	11
3	8	17.9	2.2	18
2	37	40.2	1.1	25
1	155	105.6	0.5	41
Total	201	199.8		

area of basin = 97.2 square miles

$$\text{stream frequency} = \frac{201}{97.2} = 2.07$$

$$\text{stream drainage density} = \frac{199.8}{97.2} = 2.06$$

order stream (see Figure 1 for station locations). Oxygen, temperature, turbidity, chloridity, pH and square foot invertebrate bottom samples were taken at each station. All chemical determinations were made using American Public Health Association (1955) standard methods. The second series of invertebrate collections will not be considered due to lack of preservation. Many insect genera were represented in the streams, usually in numbers too small to be treated quantitatively (only occurring once among the stations sampled). Thus only the presence or absence of an organism in a particular order stream for a specific month's collection will be considered.

The results of the collections are summarized in Table 2 for biological data and Table 3 for physical-chemical data. The biological data are arranged to show the presence or absence of an organism in a particular order stream for a specific month's collection. The physical-chemical data were computed in the following manner: any stations not directly downstream from a sewage effluent (there were two stations below sewage effluents), or not showing excessive use by cattle were considered as non-polluted. The second series of collections were considered as polluted (diluted) as they were made right after the spring floods. The "normal" values are the averages of all stations whether considered polluted or non-polluted. The "sewage" values were taken from two stations immediately downstream from the two sewage processing plants on the drainage basin. These stations were located on second and third order streams.

Discussion

Chemical Data: The pH tended to remain at constant values throughout each order, rising slightly in the higher orders. There

Table 2. Hickman Creek—Composite of Invertebrate Collections

Coll. No.	I				II	III				IV			
Order	1	2	3	4	n.c.	1	2	3	4	1	2	3	4
Taxa													
Turbellaria													
Dugesia		x											
Phagocata											x		
Hirudenaa													
Glossiphona							x						
Oligochaeta													
Enchytraeus	x	x	x	x								x	x
Lumbriculus			x	x			x						
Chaetogaster	x	x	x	x		x	x	x	x	x	x	x	x
Lepidoptera													
Elophila	x	x	x	x									
Promesia	x	x											
Coeleoptera													
Helichus		x	x	x			x						
Galerucella			x	x									
Isopoda													
Lirceus		x					x				x		
Megaloptera													
Corydalus		x	x				x	x	x				
Plecoptera													
Pteronarcys		x											
Isoperla				x									
Alloperla	x	x	x	x									
Trichoptera													
Ptilostomis		x											
unknown genus							x						
Ephemoptera													
Callibaetis		x	x										
Heptagenia		x				x	x		x				

n.c. = collections not considered

was no marked difference between the normal values and the non-polluted stream values. In the bluegrass region, where soil and substrate are carbonates, resulting in a pH for average waters of approximately 8.0, there was a distinct drop of pH in waters just below sewage effluents. This value increased with stream order as might be expected due to the influx of non-polluted waters of higher pH.

The surface temperature values for the normal stream showed a slight increase from first to second order streams, a great increase from second to third orders, and a decrease in the fourth order to a value slightly above that of the first two orders. Surface temperature values were higher in the first two orders and lower in the last two orders in non-polluted streams than for the normal stream system.

There was no marked increase in surface temperature from second to third order in non-polluted streams, the temperature increase taking place gradually up to third order and decreasing in the fourth order to a level below that of the first order. The surface temperature values for the stations below the sewage effluents were lower than the non-polluted values in both second and third order streams. The lower temperature values of the sewage effluent cannot be responsible for the high surface temperature values of the third order streams, nor can they completely account for the decrease in temperature that was found in the fourth order streams. A possible explanation for this decrease is offered by the model designed by Lehr (1963). In this model the patterns followed by groundwater in flowing into an effluent stream are illustrated. In following hydraulic principles, water will always move from an area of higher hydraulic pressure to an area of lower hydraulic pressure. Groundwater under high hydraulic pressure will flow upwards into the streams resulting in the cooling that was noted in the fourth order streams. This upwelling, although taking place very slowly, will occur in response to the increased hydraulic pressure created by the higher groundwater levels on either side of the stream. In limestone regions, groundwater may dissolve the strata. The pattern followed by the underground

Table 3. Summary of Physical-Chemical Data for the Hickman Creek Drainage Basin

Order		I	II	III	IV
pH	np	8.14	8.20	8.33	2.23
	p	8.06	7.92	8.03	8.10
	s		7.30	7.67	
Temp. (C°)	np	13.20	13.76	17.33	14.49
	p	14.00	14.67	15.29	13.32
	s		14.15	14.38	
Turb. (ppm)	np	31.57	22.09	19.33	22.78
	p	32.40	38.30	37.25	30.41
	s		81.25	62.00	
Alk. (ppm)	np	160.5	148.2	160.2	153.9
	p	151.2	141.4	149.4	146.8
			140.3	146.3	
O_2 (ppm)	np	12.16	10.76	14.00	12.98
	p	11.68	10.36	12.66	12.50
	s		8.70	11.40	
Cl	np	3.57	3.27	3.83	6.00
	p	3.30	6.80	6.92	5.42
	s		17.75	14.00	

np = non-polluted
p = polluted—"normal"
s = sewage pollution

streams thus formed will be in response to hydraulic pressure. In some cases the groundwater streams may come to the surface in the bottom of a stream. Since the fourth order stream on the Hickman drainage basin has cut through a large section of strata, several groundwater streams may intersect this order resulting in the lower temperature observed. From month to month the average temperature increase was about 5°C. The temperature values for the third order streams started approximately 2.2°C higher than the other stream orders and maintained this increase value through each series of collections.

Chloridity values for non-polluted streams decreased slightly from first to second order, increased slightly in the third order and showed a large increase in the fourth order. The values for a normal stream showed a trend just opposite to this with a large increase from first to second order, and a slight decrease from third to fourth order streams. This apparent reversal can be explained by the high values for the sewage effluent. Although the sewage effluent values decreased with increased order, they were still of significantly high concentrations to cause the reversal of the values.

A similar description and explanation can be offered for the turbidity values. In this situation the fourth order values were not increased as a result of pollution in lower stream orders as was the case with chloridity. This is probably due to a settling action on the part of the turbidity causing particles resulting in a decrease in turbidity. Without the countering effect of sewage pollution, the turbidity drops rapidly from first to second orders stabilizing around the second order value in each successive order. In both turbidity and chloridity, the decrease in concentration with increased order was probably due to the influx of non-polluted waters of the next lowest order.

The alkalinity and oxygen values are very similar. The values for each quantity almost parallel each other as do the values for pollution and non-pollution in each individual case. A decrease in alkalinity and oxygen values occurred from first to second order values followed by a marked increase to third order again followed by a slight drop in the fourth order. The sewage effluent values increased with increasing order, but as they were lower than normal values and non-polluted stream values, this could not be responsible for the third order increase. These increases do correspond with the increase in temperature. The oxygen in the waters of these streams is saturated in all stream orders. The increase in the third order of oxygen and temperature is surprising as the waters are saturated with oxygen and it would be expected that the oxygen would decrease in concentration. The supersaturated values for oxygen found in nonpolluted third and fourth order streams are equally difficule to explain in light of this inverse temperature-oxygen relationship. The relationship between temperature and alkalinity is not clear, but may also involve pH and the limestone nature of the strata in the region causing a buffering action on the part of the carbon dioxide in the formation of bicarbonates and carbonates which are measured in alkalinity.

Biological data: The aquatic caterpillar, *Promesia*, when present, seemed to be limited to first and second order streams. This insect was present only in the first set of collections, thus this idea cannot be confirmed in any way. The water beetle, *Helichus*, seemed to be typical of second and third order streams. The isopod, *Lirceus*, was found only in second order streams. The annelid, *Enchytraeus*, showed a tendency to expand from third order streams to include second order streams from February to May. The hellgammite, *Corydalus*, moved from third and fourth order streams to include second order streams from February to May. The flatworms, *Dugesia* and *Phagocata*, were both limited to second order streams, being present at different times but at the same or ecologically similar stations, *Dugesia* replacing *Phagocata* in the May collections. The idea is offered here that certain animals may serve as index organisms for a given stream order during part of the year, but not throughout the year. (Table 4).

These animals may be characteristic of, or limited to, their respective orders by one or more of the physical or chemical characteristics previously discussed. *Helichus* was characteristic of second and third order streams. These orders had maximal concentrations of chloridity and turbidity. *Lirceus* was characteristic of second order streams. This order was characterized by lower oxygen and alkalinity values. The ability to withstand low oxygen and alkalinity may enable this animal to survive and eliminate the presence of an important predator unable to withstand these conditions. The flatworms, *Dugesia* and *Phagocata*, were characteristic of second order streams. The previously noted maximal and minimal characteristics may enable them to survive or prevent an important predator from surviving. Table 4 is a summary of these relationships.

Conclusions

The Horton system of stream classification can be characterized by chemical data and some of the biological data at least through fourth order. While no one organism, of those discussed, can be used

Table 4. Summary of Possible Index Organisms for Each Stream Order.

Order I	II	III	IV
Promesia	Promesia		
	Dugesia		
	Phagocata		
	Helichus	Helichus	
	Lirceus	Lirceus	
	Enchytraeus	Enchytraeus	Enchytraeus
	Corydalus	Corydalus	Corydalus

a san index organism of a particular stream order, the presence or absence of certain combinations of animals may. The idea is presented that an animal may serve as an index organism during some parts of the year and not others. The pyhsical-chemical characteristics of the Hickman Creek drainage system may be summarized as follows:

1. First order streams were characterized by low temperatures and chloridity when compared to other stream orders.

2. Second order streams were characterized by low alkalinity and oxygen but high chloridity and turbidity values.

3. Temperature, alkalinity, oxygen, turbidity and chloridity all ahd high values in third order streams. The change in values was most noticeable for temperature values.

4. Temperature, alkalinity, and oxygen values for fourth order streams were intermediate between those for second and third order streams. Chloridity and turbidity values were generally lowest in fourth order streams.

The effect of sewage pollution was to increase values for some of the physical-chemical data (turbidity and chloridity) while leaving other factors uninfluenced. Some factors may not have been affected by the sewage pollution but might have been masked by other possible influences such as those discussed for temperature.

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FISHES OF THE GREEN RIVER BASIN IN CASEY AND LINCOLN COUNTIES, KENTUCKY

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Introduction

Green River begins near Hall's Gap in Lincoln County and extends southwest through Casey County to Mammoth Cave and then to the northwest to Henderson where it joins the Ohio River, a total distance of 370 miles. The total area of the basin, the largest in Kentucky, is 9,222 square miles, or about one-fourth of the area of the state.

That part of Green River included in this study, referred to as Upper Green River, drains an area of about 450 square miles. The major portion of this 450 square miles is found in Casey County while the rest lies in Lincoln County. Upper Green River and its tributaries consist of alternate quiet pools and shale or gravel riffles. Pools reach a depth of over ten feet and the many riffles vary from a few feet in depth to non-existence, depending upon the season. Most streams which are large enough to be called creeks in local terms flow through wide flat farmlands while the small headwaters are edged by steep slopes covered by deciduous forest. Treetops left by lumbermen can be seen as drifts as one proceeds down the river, and it was from under these drifts that many of the centrarchids reported were caught.

Methods

Horton's system of stream classification (Kuehne, 1962) was used as a basis for selection of stations and for defining the nature of the stream. United States Geological Survey topographical maps were obtained and that part of the Green River Basin which was to be studied in this survey was traced to its extreme headwaters. By using Horton's system it was determined that Green River reached order 6 below Middlesburg where Knob Lick Creek, order 5, joins the main stream. The Horton system is based upon the branching of streams, beginning at the extreme headwaters and proceeding to the mouth of the main stream. Starting with a single unbranched stream in the headwaters and continuing until it is joined by a similar stream, both of which are called order 1 streams, an order 2 stream is found. This order 2 stream continues until it is joined by another order 2 stream to form an order 3 stream. It should be pointed out that only those streams of the same order form a new order by joining; that is, if an order 3 stream is joined by an order 2 tributary, the stream still remains order 3.

Collections were made at each of 12 stations between September 15, 1962, and May 7, 1963. With the exception of one station, collections were made with common sense, minnow seines, varying in length from 4 to 15 feet. The one exception was a collection made with a gill net. Specimens were preserved in 10% formaldehyde and washed in water for 6 to 12 hours before being identified. The specimens are deposited at the University of Kentucky.

Scientific names were determined by using Eddy (1957) and Blair, et. al. (1957). The common names used were determined through the use of Special Publication No. 2 of the American Fisheries Society (1960).

Results

From the twelve collections, 35 species representing 9 families of fishes were recorded. The number of species per station ranged from 2 to 14 (Table 1). Fishes found at Stations 1, 2, and 3 were minnows (Cyprinidae) and darters (Percidae). *Semotilus atromaculatus* was the only species found at all three stations. Suckers (Catostomidae) and sunfishes (Centrarchidae) first appeared at Station 4. The studfish, *Fundulus catenatus*, (Cyprinodontidae) also appeared at Station 4. In addition to the fishes already encountered, the brook silverside, *Labidesthes sicculus*, (Atherinidae) and the catfishes, *Ictalurus melas* and *I.natalis*, (Ictaluridae) appeared at Station 7. At Station 8, the longnose Gar, *Lepisosteus osseus*, (Lepisosteidae) and the grass pickerel, *Esox americanus*, (Esocidae) were found. The number of species increased up through stations of fourth order and decreased at fifth and sixth order stations.

Using Horton's system of stream classification the following collection stations were selected and the following results obtained: (Figure 1) *Station 1.* Upper Hatter's Creek, since it is an extreme headwater, is an order 1 stream. Located in Southeastern Casey County, it originates between McClure and Sand Knob at an elevation of 1,200 ft. and drops sharply to 1,022 ft. The stream flows through deciduous forest with a ground cover of *Trillium grandiflorum, T. erectum, Phlox divaricata, Viola papilionacia,* a number of species of the family cruciferae, and other assorted herbaceous plants. The stream contained many leaves and gravels under which could be found crayfish, salamanders, helgramites and the darter, *Etheostoma caeruleum.* Other fish were all of the same species, *Semotilus atromaculatus.*

Table 1. Fishes of Upper Green River arranged by stream orders and station numbers. X—Presence.

Stream orders	1	2		3		4		5		6		
Avg. No. species/order	2	4.5		10.5		13.5		12		7.66		
Station numbers	1	2	3	4	5	6	7	8	9	10	11	12
Lepisosteidae												
Lepisosteus osseus								X			X	
Esocidae												
Esox americanus								X				X
Catostomidae												
Catostomus commersoni							X					
Hypentelium nigricans				X			X	X				
Minytrema melanops								X			X	X
Moxostoma erythrurum				X		X		X			X	
Cyprinidae												
Campostoma anomalum		X		X	X	X	X		X	X		
Chrosomus erythrogaster		X	X	X	X							
Notemigonus crysoleucas												X
Notropis ardens				X	X	X	X		X			
Notropis boops						X						
Notropis chrysocephalus		X		X	X	X	X	X			X	X
Notropis photogenis									X			
Notropis rubellus							X					
Notropis spilopterus										X		X
Pimephales notatus				X	X		X			X		
Pimephales promelas		X				X			X			
Semotilus atromaculatus	X	X	X	X	X		X					X
Ictaluridae												
Ictalurus melas							X					
Ictalurus natalis							X	X			X	
Cyprinodontidae												
Fundulus catenatus				X	X	X	X					
Atherinidae												
Labidesthes sicculus							X		X			
Centrarchidae												
Ambloplites rupestris								X		X		
Lepomis cyanellus				X		X	X	X				
Lepomis macrochirus						X		X	X	X		X
Lepomis megalotis						X	X	X	X	X		X
Micropterus dolomieui				X		X		X	X			
Micropterus punctulatus									X	X		X
Micropterus salmoides												X
Pomoxis annularis												X
Percidae												
Etheostoma blennioides						X						
Etheostoma flabellare			X	X	X			X				
Etheostoma caeruleum	X	X			X	X						
Etheostoma zonale								X				
Percina maculata							X					
Total no. of species	2	6	3	12	9	13	14	13	11	7	5	11

Station 2. At an elevation of 1,022 feet Upper Hatter's Creek is joined by another order 1 stream and continues as an order 2 stream for a very short distance with a drop of 32 feet. The flora along the banks remains the same but there is considerable change in the stream. In addition to the previously mentioned fauna, the following minnows (Cyprinidae) appeared: the stoneroller, *Campostoma anomalum;* the redbelly dace, *Chrosomus erythrogaster*; the common shiner,

Notropis chrysocephalus; and the flathead minnow, *Pimephales promelas.*

Station 3. Upper True Branch, a tributary of Bush Creek, is an order 2 stream and originates at an elevation of 1,000 feet. It then flows through a pasture, which is stocked with dairy cattle, dropping 140 ft. before increasing in magnitude. The flora consists of pasture grasses, *Salix sp.*, and *Platanus occidentalis.* Fishes found here were: the fantail darter, *Etheostoma flabellare;* and the minnows, *Chrosomus erythrogaster* and *Semotilus atromaculatus.*

Station 4. At Jumbo, in Lincoln County, Green River is an order 3 stream. Elevation is approximately 990 ft. and the gradient has decreased to the point that intermittant shale pools and gravel riffles are formed. The fish found on riffles were: the fantail darter, *Etheostoma flabellare;* the hogsucker, *Hypentelium nigricans;* and the minnows, *Campostoma anomalum, Pimephales notatus,* and *Semotilus atromaculatus.* The fishes generally found in the pools were: the golden redhorse, *Moxostoma erythrurum;* the studfish, *Fundulus catenatus;* and the centrarchids *Lepomis cyanellus* and *Micropterus dolomieui.*

Station 5. True Branch is an order 3 stream which drains directly into Brush Creek. It is a continuation of the stream which is listed in station 3 and has the same flora. True Branch differs from the previous order 3 stream in that it has no representatives of the Centrarchidae or Catostomidae but has one more member of the Percidae, *Etheostoma caeruleum.*

Station 6. Carpenter's Creek is a slate bottomed stream which drains northeastern Casey County. Collections were made at Kidd's Store at which point the creek is an order 4 stream. Steep banks border the stream on the south side and are covered by *Hepatica sp., Phlox sp., Rhus sp.*, and shrubby members of the Ericaceae. *Salix sp.* was abundant in the edges of pools. Families of fishes best represented were Cyprinidae and Centrarchidae. The former was represented by: the stoneroller, *Campostoma anomalum; Notropic ardens; N. boops; N. chrysocephalus;* and *Pimephales promelas.* Centrarchids found were: the green sunfish, *Lepomis cyanellus;* the bluegill, *L. macrochirus;* the longear sunfish, *L. megalotis;* and the smallmouth bass, *Micropterus dolomieui.* Percidae was represented by two species, *Etheostoma blennioides* and *E. caeruleum.* Catostomidae and Cyprinodontidae were each represented by only one species, *Moxostoma erythrurum* and *Fundulus catenatus respectively.*

Station 7. Pine Lick Creek, order 4, is formed by the union of Peltis Fork and Pine Lick Creek, order 3. This is a shallow creek with alternate slate and gravel riffles with few pools. A total of 14 species were collected here with an addition of 2 new families, Ictaluridae and Atherinidae. The family Ictaluridae was represented by 2 species; the black bullhead, *Ictalurus melas* and the yellow bullhead, *I. natalis.* Atherinidae was represented by the brook silverside, *Labidesthes sicculus.* The white sucker, *Catostomus commersoni* and the rosyface shiner, *Notropis rubellus* appeared here but belong to families which were already represented. This was the stream from which the maximum number of species was collected.

Station 8. South Fork is an order 5 stream which drains southern Casey County, joining Green River near Dunnville. At the point of collection the elevation is about 760 ft. In this stream Centrarchids became most abundant with 5 different species represented. They were: the rockbass, *Ambloplites rupestris;* the green sunfish, *Lepomis cyanellus;* the bluegill, *L. macrochirus;* the longear sunfish, *L. megalotis;* and the smallmouth bass, *Micropterus dolomieui.* Two new families, Lepisosteidae and Esocidae, were encountered. Species collected were the longnose gar, *Lepisosteus osseus,* and the grass pickerel, *Esox americanus. Minytrema melanops* also appeared for the first time.

Station 9. Just below the Middleburg Bridge, Green River is an order 5 stream, characterized by alternate slate riffles and pools. Many of the pools reach a depth of over 6 feet and the riffles were about 1 foot deep at the time of collection. Three new species were added to the checklist at this station. They were: *Etheostoma zonale, Micropterus punctulatus,* and *Notropis photogenis.*

Station 10. Above the mouth of Calhoun Creek, Green River (order 6) is shaded by many willows and sycamores. The river at this point consists of long quiet pools divided by short shallow riffles. The elevation is about 770 ft. All of the fish collected at this station belonged to two families, Centrarchidae and Cyprinidae, with centrarchids being the most abundant. No new species were added.

Station 11. The Barger Hole (order 6), just above Liberty, is a long deep pool which is a favorite fishing site with many of the natives of the region. The collection here consisted entirely of rough fish, except for the common shiner. No new species were found.

Station 12. At the base of the Walnut Hill Bluffs, backwaters of Green River (order 6) form what the local people call "The Lagoon." "The Lagoon" reaches a depth of 5 feet, is crisscrossed with old stave fences and remains muddy at all times. A dense deciduous forest borders it on the southwest and open fields on the northeast. Rocks extend out into the water and holes under them will accommodate half of a man. Three new species were found at this station. Two of them, the white crappie, *Pomoxis annularis* and the largemouth bass, *Micropterus salmoides* belonged to the predominant family, Centrarchidae. The other was the golden shiner, *Notemigonus crysoleucas.*

The Kentucky Department of Fish and Wildlife Resources is conducting a longitudinal study dealing with that part of Green River involved in this study (Charles, 1963). Four checklists from which the following information was obtained have resulted from this study (Table 2). All collections were from order 6 streams.

A. In 1960, two areas in Casey County were sampled with rotenone. These areas were the Barger Hole, 2 miles upstream from Liberty, and the Rock Hole, 2 miles downstream from Liberty. From the two areas combined, specimens were collected representing 9 families and 36 species.
B. In 1961, the Rock Hole was again sampled with rotenone. This one area alone yielded specimens representing 7 families and 27 species. (Fig. 1).
C. The 1962 sample was taken from the Rock Hole and an area one tenth of a mile below the mouth of Allen Creek. Specimens collected represented 10 families and 5 species.
D. The 1963 rotenone samples were taken in the same areas as 1960. Specimens represented 8 families and 31 species.

Discussion

If, as Kuehne (1962) proposes, there is a relationship between fish distribution and the Horton stream classification, the number and diversity of fishes should increase with each successive increase in stream order. According to the present study this held true up through order 4 and then there was a general decrease in the number of species with each of the next two orders. Order 1 had an average of 2 species, order 2 had 4.5, order 3 had 10.5, and order 4 had 13.5; thus giving the expected increase. Order 5 had an average of 12 species and order 6 had an average of 9 if the gill net collection is excluded. This type of collection will not give a clear picture of species present because minnows and darters would not be caught in it.

Contrary to these results, the findings of the Department of Fish and Wildlife Resources would indicate that there is a great increase in the number of species from the order 4 stream up to the order 6 stream. Combining the findings, Kuehne's theory can be substantiated, since at least through order 6, as stream order increases, the number and diversity of species of fishes increases.

The discrepancy between these findings and those of the Department of Fish and Wildlife Resources can be explained in the following way. While rotenone, a poison, is so effective that samples of all species are obtained, many specimens might have been missed by seining in the deep holes of order 5 and order 6 streams. In addition to being deep, holes are long and wide, permitting fish to swim around the seine as well as over or under it. The greatest number

Table 2. Fishes of Upper Green River: A summary of check-lists showing the findings of the Kentucky Department of Fish and Wildlife Resources; 1960, 1961, 1962, and 1963 (Charles, 1963).

X-Presence

Stream order	6	6	6	6
Station number	A	B	C	C
Petromyzontidae				
Lampetra aepyptera	X			
Lepisosteidae				
Lepisosteus osseus	X	X	X	X
Clupeidae				
Dorosoma cepedianum	X		X	X
Esocidae				
Esox americanus vermiculatus		X	X	X
Cyprinidae				
Campostoma anomalum	X		X	X
Carassius auratus	X			
Cyprinus carpio	X			X
Hypopsis amblops			X	
Hybopsis dissimilis			X	
Hybopsis micropogon			X	
Notropis ardens			X	
Notropis ariommus	X			
Notropis atheriniodes	X	X		X
Notropis boops			X	
Notropis cornutus	X	X	X	X
Notropis leuciodus			X	
Notropis photogenis			X	
Notropis rubellus			X	
Notropis spilopterus	X	X	X	
Notropis volucellus			X	
Notropis whipplei		X	X	
Opsopoeodus emiliae			X	
Pimephales notatus	X	X	X	X
Semotilus atromaculatus			X	
Catostomidae				
Catostomus commersoni			X	X
Hypentelium nigricans	X	X	X	X
Minytrema melanops	X	X	X	X
Moxostoma anisurum			X	X
Moxostoma breviceps	X			X
Moxostoma carinatum			X	
Moxostoma duquesnei	X	X	X	
Moxostoma erythrurum	X	X	X	X
Ictaluridae				
Ictalurus melas	X	X	X	X
Ictalurus natalis	X	X	X	X
Ictalurus punctatus	X		X	X
Noturus miurus	X	X	X	
Noturus species (Green River system)	X			
Pylodictis olivaris	X	X	X	X

(*Continued*)

Table 2—(Continued)

Station number	A	B	C	D
Cyprinodontidae				
Fundulus catenatus	X		X	
Fundulus notatus			X	
Centrarchidae				
Ambloplites rupestris	X	X	X	X
Chaenobryttus gulosus		X		X
Lepomis cyanellus	X		X	X
Lepomis macrochirus	X	X	X	X
Lepomis megalotis	X	X	X	X
Lepomis microlophus		X	X	
Lepomis sp. x sp.	X		X	X
Micropterus dolomieui	X		X	X
Micropterus punctulatus	X	X	X	X
Micropterus salmoides	X	X	X	X
Pomoxis annularis	X	X	X	X
Percidae				
Etheostoma blennioides	X	X	X	X
Etheostoma caeruleum			X	
Etheostoma camurum			X	
Etheostoma flabellare	X		X	
Etheostoma kennicotti	X	X	X	
Etheostoma nigrum			X	
Etheostoma stigmaeum			X	
Etheostoma zonale			X	
Percina caprodes	X	X	X	X
Percina cymatotaenia			X	
Percina macrocephala			X	
Percina maculata		X	X	X
Atherinidae				
Labidesthes sicculus			X	
Total number of species	36	27	56	31

of species collected in an order 6 stream, using seines, was 11, while using rotenone, the State Department's smallest collection consisted of 27 species. This indicates that as compared to rotenone seines are very ineffective in sampling large streams.

While making collections, certain occurrences which may suggest botanical problems were noted. *Salix sp.* (Willows) seem to appear on the banks of order 2, 3, and 4 streams progressively and are then replaced by *Platanus occidentalis* (Sycamore) to some extent on the banks of order 5 streams and then more extensively so with the order 6 streams. Upon superficial observation, it was also noted that there seems to be a close relationship between the distribution of algae and stream orders.

Summary

1. Between September 15, 1962, and May 7, 1963, a study was made to determine the distribution of fishes in Upper Green River in Casey and Lincoln counties.

2. Combining these findings and those of the Kentucky Department of Fish and Wildlife Resources it was found that there were 11

families of fishes in Upper Green River consisting of a total of 69 species.

3. It was found that as stream order (Horton's system) increases the number and diversity of species of fishes increases.

4. Findings are discussed with regard to distribution of fishes by stream orders, the inefficiency of seines, and observations which suggest a need for botanical studies related to stream order.

Acknowledgments

I wish to acknowledge the assistance of Dr. Keuhne in the identification of fishes and the assistance given in collecting by my students at Hustonsville High School. Students assisting were Pete Foster, James Hargis, Walter Daugherty, and Gary Rousey. This paper has been greatly enriched by the use of information obtained from Mr. James R. Charles, Kentucky Department of Fish and Wildlife Resources.

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EFFECT OF AQUEOUS EXTRACTS OF LYOPHILIZED ASCITES TUMOR CELLS AND SUPERNATE ON THE OXYGEN UPTAKE OF FRESH ASCITES TUMOR (S-37)

SISTER VIRGINIA HEINES, SISTER JULIA CLARE FONTAINE, SISTER MARY ADELINE O'LEARY, SISTER MARY IDA COSBY*, J. C. FARDON,** AND LEO NUTINI.**

Catherine Spalding College, Louisville, Kentucky

For the past several years the aqueous extracts of lyophilized ascites cells and supernatant have been used in this laboratory to determine the effect of the oxygen uptake of the fresh ascites tumor (S-37). Reports in the literature[1] have shown the ability of certain fractions derived from the transplanted dbrB mammary adenocarcinoma to induce partial resistance to the growth of the tumor in DBA/1 mice. Since this fraction tends to accelerate the growth of the tumor it may be related to the factor which has been characterized as a glycoprotein[2] or a lipoprotein.[3] Menkin[4] has reported an acetone-insoluble growth stimulating protein in inflammatory exudates. No studies on the isolation of depressive stimulatory factors from the ascites tumor have been reported in the literature.

Experimental

Transplantation of the stock tumor in a line of Rockland mice was carried out weekly using an inoculum of 0.10 ml., 1:5 dilution intraperitoneally. Of the forty animals used in this work ninety-five per cent were male mice and the age varied from 4 to 8 weeks. The ascites tumor was collected by intraperitoneal puncture on the sixth or seventh day after inoculation. This stock tumor was suspended (1:2) in Tyrode's solution and six drops of the suspension plus 3 drops of Tyrode's placed in the flask of micro-respirometer[5] as a control. The experimental flask contained, in addition to the six drops of the suspended tumor, three drops of a water extract of lyophilized supernatant or cells. Sterile conditions were maintained throughout the runs. Respirometry studies were carried out in a water bath at 37°C. ± 0.01° for three or four hours, and calculations made for oxygen uptake (QO_2) in cumm/mg dry weight/hour.

The water extracts of supernate and cells were prepared as follows: as soon as the ascites tumor was removed from the sacrificed animal, it was centrifuged for ten minutes at 2500 rpm. The super-

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nate was removed, lyophilized and stored at −10°C. until ready for use. The ascites tumor cell separation was done according to the method of Roitt,[6] then lyophilized and stored. The aqueous extract of either lyophilized cells or supernate was prepared by placing several spatulas of the dried material in a graduated centrifuge tube and diluting to a one milliliter volume with double distilled water. Dried weights of the stock tumor and extracts were used in the calculation of the QO_2. Three drops of the clear extract were placed in the experimental flasks with the 6 drops of 1:2 suspension.

For comparison, counts were made daily on each animal for total tumor cells, leucocytes, and mitotic figures. Blood cell counts proved insignificant. The ratio of the leucocytes to total tumor count, averaged for the forty animals, was 1:6, and the mitotic figures, calculated as total tumor cells, was 10%. The results of the forty experiments using 20 animals for each extract are given in Tables I and II.

The constancy and reliability of the micro-respirometer were determined with a suspension of baker's yeast in Ringer-phosphate-glucose solution.

Calculation of oxygen up-take is made by the following equation:

$$QO_2 = \frac{RKF}{W} \,\ldots\ldots\, \frac{T}{T\text{-}t} \text{ (if less than an hour)}$$

R = pipette reading in cu.mm.

K = pipette constant

F = factor for reduction to N.P.T.

W = dry weight of tissue in mg.

T = Time in minutes

Results And Discussion

The results of the respirometry studies on forty animals are given in Tables I and II. Average of the depression values on 20 animals amounted to 51% and stimulation values on 20 animals amounted to 59%.

It is significant that the unstableness of the inhibitory factor we found is in agreement with the work of others along this line.[7] Once a week for three weeks we used the same water extract (stored in the ice box between runs) of the lyophilized supernate to determine if its strength decreased on standing. When first used the water extract showed 41% depression of the tumor cells. After storage in ice box the value fell to 10%, and at the end of second week it rose to 13%. Stability of cell extract has yet to be determined.

There are variations in these results which can be attributed to individuality differentials. All dry weights were made on the stock tumor before suspension in Tyrode's solution. The same micropipette was used for the dry weight determinations and for charging the respirometer flasks. Results indicate a definite depression of activity of tumor cells by the aqueous extract of the supernate, and a stimulation of the cells by the aqueous extract of the cells. Other workers[7] have found both an inhibitory and stimulatory factor in tissues, but no reports have been made on these factors occurring in the ascites tumor (S-37). It will be important to find out if the stimulatory substance dominates in an actively growing tumor.

Table 1. Effect of Aqueous Extract of Lyophilized S-37 Cells on the QO_2 of S-37 Cells

No. of Mice	Average Tumor wt. mg/6 drops 1:2	Water Extr. mg/3 drops	Average QO_2 Control cumm/hr/mg	Average QO_2 Expr. cumm/hr/mg	Average Stimulation %
5	5.3	1.10	2.2	3.7	68
5	4.7	0.68	3.5	5.3	51
5	4.0	0.67	5.5	6.4	20
5	4.1	0.49	2.8	6.0	100

Table 2. Effect of Aqueous Extract of Lyophilized S-37 Supernate on the QO_2 of S-37 Cells

No. of Mice	Average Tumor wt. mg/6 drops 1:2	Water Extract mg/3 drops	Average QO_2 Control cumm/hr/mg	Average QO_2 Expr. cumm/hr/mg	Average Depression %
5	5.5	1.1	3.9	1.5	61
5	3.1	1.8	6.3	1.8	71
5	3.5	0.6	5.0	2.6	48
5	2.3	1.3	3.6	2.6	27

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BOTANY IN KENTUCKY SINCE 1914

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The story of botany in Kentucky since 1914 is that of the persons who have been associated with the science through their contributions to the literature of botany or through their inspiration of younger people who, themselves, have contributed to the botanical literature and are, consequently, known to those persons, like your author, who have come along in this field in later years. In a paper of this type obviously it is not possible to include all who might be included, but in the words of the editor of this journal, those people are discussed herein "who are either retired, deceased or have been gone from the state long enough to lead one to believe that their absence is permanent." This means that some very fine teachers of botany will be excluded undoubtedly since they are to be remembered only by their students and not by their literary contributions.

One of the persons who had a great influence upon botany in Kentucky particularly in the third and fourth decades of this century was Dr. Frank T. McFarland. Dr. McFarland was born in Sunbury, Ohio, May 12, 1886 (1). He took his B. S. A. degree at Ohio State in 1912, the M. S. at Michigan in 1916 and his Ph.D. in Plant Pathology at Wisconsin in 1921. Whether by choice or necessity it is not presently known, for Dr. McFarland's chief contributions were made, not in lower cryptogamic botany as might be expected on the basis of his doctoral work, but in the vascular plants, especially the flowering plants, and these were made by his students primarily. Dr. McFarland was successively an instructor at the University of Kentucky, 1912-13; assistant professor, 1913-20; associate professor, 1920-22 and professor and head of the Botany Department from 1922-42. During the course of his graduate studies, he had served first as an assistant and then as an instructor in the department at Michigan in the summers of 1914 and 1915, respectively.

Upon assuming the position of head of the department at Kentucky, Dr. McFarland's interest in the vascular plants became apparent through the master's theses written by his students: Anderson on Kentucky Graminales (1924); Shacklette on the flora of Union County (1937); McCoy on the ferns and fern-allies of Kentucky (1938); Plymale writing on the flora of Wayne Co., West Virginia (1940); Harvill on the Compositae of Kentucky (1941); Rogers on the flora of McCreary Co. (1942); Tosh on the flora of Raleigh Co., West Virginia

(1942), and McFarland writing on the flora of Jessamine Co. (1946). Only the theses by McCoy, Plymale and Tosh were published. In 1942 Dr. McFarland published his "Catalogue of the Vascular Plants of Kentucky" in which he listed all the species of vascular plants known from the state and accessioned in the herbaria of the Botany Department and the Agricultural Experiment Station (2). This monumental work included 1702 species, varieties and forms—the largest number recorded in a single publication concerned with the vascular plants of the state. While this publication was subsequently criticized for some of its shortcomings [Peattie, 1946 (3)], it nevertheless, stands today among the two most complete works of its type for Kentucky.

Dr. McFarland was an excellent teacher as attested to by his many former students. He led the first botanical renaissance in Kentucky since the days of Rafinesque, Short and Peter, and he left an imprint on Kentucky botany that will long be felt. His reputation, undoubtedly, would have been greater but for the great fire of August 1948 in which the herbarium, which he had accumulated in twenty-five years or more of labor, was totally destroyed. Fortunately, a few duplicates of some of the collections, notably some of Shacklette's, had been sent to other herbaria. Otherwise, we would have no records of this period of productive activity.

A colleague of Dr. McFarland paid him what might be considered the supreme compliment for a taxonomist. Dr. B. B. McInteer once said that every plant Dr. McFarland pressed was a work of art. Those who are in a position to know would be in complete agreement. Dr. McFarland retired in 1956, and he now lives in Berea, Kentucky.

The mention of the name of Dr. Charles Albert Shull comes as a surprise to many in a discussion of botany in Kentucky since 1914. Dr. Shull was born in Miami Co., Ohio, on August 1, 1881 (4). He took his B.S. at Chicago in 1905 and his Ph.D. there in 1915. From 1906 to 1908 he was assistant professor of biology at Transylanvia, and he was professor of biology and geology there from 1908-1912. In the period 1918-1921, he served at the University of Kentucky as professor of plant physiology and Chairman of the Botany Department. Had Dr. Shull remained in Kentucky, he probably would be considered here among our outstanding contributors to botany in the state. As it has developed, he became one of the truly outstanding plant physiologists in the United States in the first half of the twentieth century, but most of his contributions were made and his honors were received after he left the state.

As we have seen above, two patterns have been followed in floristic work in Kentucky. One has consisted of county floras, and the other has involved intensive studies of single families or orders. The first county flora of the twentieth century in the state was that of Sister Rose Agnes Greenwell, who, in 1935, published her "Flora of Nelson County, Kentucky" (5). Sister Rose Agnes was born in Leonardtown, Maryland, January 8, 1894 (6). She was granted her A.B. degree at Notre Dame in 1926 and the M.S. at Marquette in 1927. The Ph.D. was conferred on her at Catholic University in 1935. The Nelson County flora was her doctoral dissertation, and in it she included all the vascular species she had collected in the county in addition to keys to the families, genera and species. Economic species of each family were listed whether actually represented in the flora or not. The 863 species reported for Nelson Co. represent the largest number of species given in the published literature for any county in Kentucky.

Sister Rose Agnes went to Nazareth Junior College in 1928 as an instructor in biology. She was made head, Department of Biology, Nazareth College, Louisville, in 1931, and she has occupied this position since that time. Although it has become increasingly difficult for her to do field work, Sister Rose Agnes maintains an active interest in taxonomy and floristics.

Thomas N. McCoy was mentioned earlier in the material dealing with Dr. McFarland. Mr. McCoy was born on a farm near Calvert City, Kentucky, November 11, 1905. His graduation from high school in that city in 1926 was followed by teaching for three years in the county schools of Marshall and Livingston Counties. In 1930 he was appointed principal of an elementary school in Catlettsburg. Meanwhile, between 1926 and 1933, he had undertaken college work at Murray State College, and in the latter year he was graduated with a B.A. degree. Graduate work was pursued at the University of Kentucky in the summers of 1933, 1934 and 1935, and these efforts culminated in the completion of the M.S. degree in 1936. His thesis, "The Ferns and Fern-allies of Kentucky" was published (7), and it constituted such a fine contribution that even today Mr. McCoy is regarded as the leading authority on the ferns of Kentucky. The fact that he was requested to lead the American Fern Society's Kentucky foray in August 1961 attests to the high esteem with which he is regarded by other fern specialists elsewhere in the United States. He continues to reside in Catlettsburg where he has been superintendent of schools for several years. In addition to his M.S. thesis, he has published three shorter papers dealing with Kentucky ferns.

A contemporary of Thomas N. McCoy was Hansford T. Shacklette, who was born in Henderson, Ky., on September 1, 1914. He was graduated from Morganfield High School in June 1931, and the following fall he entered the University of Kentucky. In June 1935 he was graduated from the university with a degree of B.S. in Agriculture whereupon he entered the Graduate School in Lexington and completed his M.S. degree in Lexington in 1937. Dr. Shacklette served as instructor in botany at the university from 1937-41. Although his master's thesis on the flora of Union County was never pulished, Dr. Shacklette became one of the organizers of the Kentucky Flora Project with botanists at several institutions of higher education elsewhere in the state. In connection with this undertaking he complied a very noteworthy literature survey of taxonomic botany for Kentucky which was mimeographed and distributed in 1940, and additional references were included in a supplement which was published (mimeo) in 1941.

Subsequently, Dr. Shacklette taught for several years at Georgetown College, Kentucky. He was granted the Ph.D. degree at Michigan in 1963, and since that time he has been associated with the United States Geological Survey, Department of the Interior, in phytogeochemical studies.

No review of botany in Kentucky in the period from 1914 to the present would be complete without mention of Dr. E. Lucy Braun, who, with the possible exception of Dr. McFarland, is probably the outstanding authority on the taxonomy of the higher plants of the state. This little lady trudged the trails and dry-weather roads of eastern Kentucky and amassed a wealth of information on the ecology of that area and the distribution of our plant species. Dr. Braun was born in Cincinnati, April 19, 1889 (8). She received the A.B., A.M. and Ph.D. (botany) degrees from the University of Cincinnati in 1910, 1912 and 1914, respectively. In 1912 she spent a while at the University of Chicago. In the University of Cincinnati she served as an assistant in geology, 1910-13; instructor in botany, 1914-17; assistant professor, 1923-27; associate professor, 1927-46; professor of plant ecology, 1946-48 and emeritus professor from 1948 to the present. Many honors have come to Dr. Braun. Among these were her selection as a Guggenheim fellow in 1943-44, recipient of the Pope medal in 1952, election as vice-president of the Ecological Society of America in 1935 and its president in 1950 and recipient of a Certificate of Merit from the Botanical Society of America in 1956. Her "Annotated Catalog of the Spermatophytes of Kentucky" (1943) (9) is a volume the systematic botanist in Kentucky can scarcely afford to be without. 1636 species, varieties, forms and hybrids are included in this work. "The Deciduous Forests of Eastern North America" (1950) is the definitive work on this subject. In addition, Dr. Braun has written "The Woody Plants of

Ohio" (1961) and approximately twenty shorter contributions on the ecology and taxonomy of Kentucky plants as well as numerous other papers of an ecological or taxonomic nature. Dr. Braun ranks as the outstanding botanist of this period of Kentucky botany.

An important contributor to Kentucky botany was Dr. P. A. Davies of the University of Louisville. Dr. Davies was born in Fort Collins, Colorado, February 10, 1896 (8). He attended Colorado Agricultural College and was granted his A.B. degree by that institution in 1922 and the M.S. in 1923. Next he went to Harvard University where he received the Ph.D. in general physiology in 1926. Throughout his career as a college professor he remained at the University of Louisville. He was appointed assistant professor of biology in 1926, associate professor in 1928, professor in 1929 and chairman of the Department of Biology in 1931, a position which he held until 1956. In addition, Dr. Davies was chairman of the Division of Natural Sciences, University of Louisville, from 1934 until his death on January 4, 1961.

Dr. Davies' early research was on the physiology of seed germination, morphology and anatomy, and gradually he became interested in plant distribution, floristics and taxonomy in which fields his later contributions are to be found. Two of his more important papers were: A preliminary list of the vascular plants of Meade County, Kentucky and A preliminary list of the vascular plants of Mammoth Cave National Park. The influence of Dr. Davies is to be found also in his students among whom were: Charles R. Gunn, A flora of Bernheim Forest, Bullitt Co., Kentucky, and several other shorter papers; George Kellerman, A survey of the aquatic plants of western Kentucky; James A. Mathews, A flora of Oldham County, Kentucky; Mrs. Harvey B. Lovell, The vascular plants of the Kleber Songbird Sanctuary, Owen County, Kentucky, and others. Surely, Dr. Davies' influence on Kentucky botany will be felt for many years to come.

Notable among those who have made contributions to botany in Kentucky in recent years is Dr. Clyde F. Reed, Howard University, Washington, D.C. Dr. Reed was born in High Point, North Carolina, April 30, 1918 (8). He took his A.B. degree at Loyola College (Maryland) in 1938, the M.A. at John Hopkins in 1940 and his Ph.D. in biology at Harvard in 1942. After completion of his doctorate, Dr. Reed worked as a food chemist and microbiologist in Maryland from 1942 to 1947 when he became professor of Biology at Morehead State College. He remained there until 1950, and it was during this time that he became interested in the Kentucky flora, an interest which has persisted until the present. In 1950, Dr. Reed went to Baltimore Junior College, Baltimore, Maryland, where he remained until assuming his present position at Howard University in 1961. His main contributions have been journal papers dealing with the ferns and fern-allies of Kentucky and *Trillium* in Kentucky. It is largely due to his efforts and those of McCoy (7) that the ferns and fern-allies are the most completely known groups of plants in the vegetation of Kentucky.

Dr. B. B. McInteer is affectionately remembered by many of his former students at the University of Kentucky. He was born March 25, 1887, at Sulfur Well, Kentucky (10). After Dr. McInteer took his B.S. degree at the university in 1917, he served for two years in the army. For three years, 1920-23, he was a county agent. In 1926 he was granted the M.S. degree by the university, and Ohio State awarded him the Ph.D. degree in botany in 1932. In his service to the people of the state as a teacher, he was an instructor in botany at the University of Kentucky, 1924-25; assistant professor, 1925-33; and associate professor from 1933 until his retirement in 1957. Dr. McInteer was associate editor for Kentucky of Castanea, the journal of the Southern Appalachian Botanical Club, from 1953 through 1962. He was primarily interested in plant ecology, and most of his scientific papers dealt with some aspect of this subject. Others were concerned with algology, floristics and plant distribution. When the building housing the Botany Department was destroyed by fire in August 1948, Dr. McInteer was to a large extent instrumental in establishing a new herbarium. Following his retirement he moved to Louisville where he still resides.

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TWO GREAT KENTUCKY ORNITHOLOGISTS

GORDON WILSON,
Bowling Green, Kentucky

Between the time of John James Audubon and the present-day students of ornithology in the state the two greatest names in this science are Charles Wickliffe Beckham (1856-1888) and Leon Otley Pindar (1870-1936). Both did their distinctive work when they were quite young: Beckham died of tuberculosis before his thirty-second birthday; Pindar became a physician and gave up his hobby of ornithology almost entirely until his later years, when invalidism prevented his being very active as an observer.

Beckham, an older brother of J. C. W. Beckham, governor of Kentucky from 1900 to 1908, was reared in Bardstown, early became an observer of many phases of wild life, took special work in Harvard under Professor Nathaniel Southgate Shaler, worked in the National Museum at Washington, and, in addition to his Kentucky studies, published some valuable scientific articles on the birds of Pueblo County, Colorado, and Bayou Sara, Louisiana. A posthumous article about his studies in southwest Texas is even more highly regarded than his studies in Kentucky, Colorado, and Louisiana. He was an avid collector: hundreds of his specimens were sent to the National Museum, and for a long time the state was represented almost wholly by his collection there.

His most memorable publication dealing with Kentucky birds, "A List of the Birds of Bardstown, Kentucky," appeared in 1883 in the *Journal of the Cincinnati Society of Natural History* (6:136-147, July). It listed 167 species and represented Beckham's observations since about 1877. A revision of the article, listing 171 species, appeared in the publications of the Kentucky Geological Survey in September, 1885. An excellent biographical and critical sketch of the life and achievements of Beckham is Harvey B. Lovell's "Charles Wickliffe Beckham, Ornithologist," *Kentucky Warbler,* 33:19-26, 1957.

Exactly at the same time of Beckham's early publications Pindar was collecting at Hickman, Fulton County, and at Reelfoot Lake. Beginning his study of birds at fourteen, he published at seventeen his "A List of Birds of Fulton County, Kentucky" in *Ornithologist and Oologist* (12:54-55 and 84-85, 1887). In 1888 Pinder was one of the founders of the Wilson Ornithological *Club* (now called *Society*). In 1889, when he was barely nineteen, he published a revision of his Fulton County article in *Auk* (6:310-316). The original article had listed 122 species of birds; the revision listed 182. In 1889 he went away to medical school and was prevented from making any very extended further study of the area except for some ten weeks in the spring of 1890 and from March 1, 1892, to November 1, 1893. After years of service as a physician in other parts of the state and in the United States Army, he made his home in Versailles. Broken in health and unable to practice very much after 1922, he still kept up his interest in ornithology. In April, 1923, he, Mr. Brasher C. Bacon, and I organized the Kentucky Ornithological Society, and he became the first president of that organization.

From my first acquaintance with Dr. Pindar I began to urge him to revise his earlier studies of Fulton County. At that time I was the secretary of the Wilson Ornithological Club and, *ex officio,* a member of the editorial board of the *Wilson Bulletin,* the organ of the club. Dr. Lynds Jones, the editor of the magazine, urged me to find some good material; Dr. Pindar agreed to write out his revision if I would arrange it for publication. He would send sections of the revision to me that h ehad typed as well as his hands would permit or would sometimes write out in his difficult penmanship large parts of the article. The revision included his later experiences, mentioned above, and contained the names of 273 species; he, or I, or the typesetter omitted the Osprey; hence the actual list as printed contains only 272 names. It appeared as "Birds of Fulton County, Kentucky," in 1925 in the *Wilson Bulletin* (37:67-78 and 163-169); the magazine also brought out as a reprint the two articles that make up the revision.

Beckham's articles about the birds near Bardstown became the basis for the studies of Benedict J. Blincoe, also of Bardstown, who brought out his own "Birds of Bardstown, Nelson County, Kentucky," in 1925 (*Auk* 42:404-420). This article reviews Beckham's studies of forty years earlier and adds Blincoe's own observations from 1911 to 1921.

Both Beckham and Pindar had many things in their favor when they were so active in their work. There was no limit on hunting or collecting, or none that seems to have been enforced. Since Pindar lived so near Reelfoot Lake, he included that area in his study and had a standing agreement with hunters to let him examine the waterfowl that they had killed there. The wide discrepancy between Pindar's 273 species and Beckham's 171 is easily explained by referring to the territory studied. Bardstown is not near any large river and has only small farm ponds; Hickman is on the Mississippi River and is near Reelfoot Lake and thousands of acres of marshy land. Pindar lists 87 water species, Beckham only 26; Pindar lists 18 birds of prey, Beckham 8. Of land birds Pindar lists all the 37 warblers commonly found in the state, and Beckham has 34 of them, his omissions being the Prothontary, the Swainson's, and the Worm-eating. In general, the two lists agree amazingly on land species.

Pindar's list is lengthened because he has a number of species and subspecies: Double-crested and Florida Cormorants, Canada and Hutchin's Greese, Horned and Prairie Horned Larks, Loggerhead and Migrant Shrikes. He also lists the Purple and the Bronzed Grackles, now regarded as one species. Both list the Passenger Pigeon; it must be remembered that the species was still to be found in small numbers for some time after the late 1880's; I saw one that my brother killed in 1892. Pindar also lists the Carolina Paroquest and the Ivory-billed Woodpecker.

Species on Pindar's list that could be called unusual are fairly numerous; realizing this, in his 1925 revision of his article he took pains to give specific dates and other necessary facts. A very large percentage of these oddities have been recorded by Mr. A. F. Gainer and other recent observers at Reelfoot Lake. Here is a list of the unusual species: White Pelican, Whistling Swan, Trumpeter Swan, Brant, White-fronted Goose, Cinnamon Teal, Barrow's Goldeneye, Swallowtailed Kite, Swainson's Hawk, Whooping Crane, Yellow Rail, Longbilled Curlew, Eskimo Curlew, Laughing Gull, Franklin's Gull, Gullbilled Tern, Raven, Black-capped Chickadee, Northern Shrike, European Tree Sparrow, Painted Bunting, Pine Grosbeak, and Common Redpoll.

To this day Pindar's list for a single county in Kentucky and parts of two counties in Tennessee—less than 400 square miles—remains the largest list for such a small area, anywhere in the state, or neighboring states, I suspect. Here are some comparisons with his list of 273 species for the general area of Fulton County, Kentucky, and parts of Obion and Lake Counties, Tennessee: the Louisville list, representing Jefferson and adjoining county areas, has 286 species, the combined work of some twenty able ornithologists, headed by Burt L. Monroe, Sr.; the list for south-central Kentucky for an area four times as large as Pindar's area is only 262 species. This latter list repersents more than fifty years of observation by Gordon Wilson, plus decades of study by Drs. Russell Starr and L. Y. Lancaster.

This article is in no sense a defense of Pindar; his work speaks for itself. He remains the best ornithologist of his area and, until very recently, the only one of note, so far as the Kentucky side of his study area is concerned. But Pindar has been neglected and ignored by many writers on Kentucky scientific study. In the 1894 "Preliminary

List of the Vertebrate Animals of Kentucky," the author, Harrison Garman, did not refer to Pindar's list and has only 227 species for the entire state. Similarly, W. D. Funkhouser, in his *Wild Life in Kentucky,* 1925, though he lists Pindar's publications in his bibliography, does not quote from him on a single species. J. D. Figgins, in *Birds of Kentucky,* 1945, barely mentions Pindar a few times. Since Figgins left no bibliography, it is not certain that he had ever seen Pindar's 1925 revision of the 1889 article.

In Blincoe's 1925 article he says that of 167 species he had been unable, in ten years, to find 29 around Bardstown. Some of these 29 are doubtless still to be found in the area, such as Pied-billed Grebe, Blue-winged Teal, Green-winged Teal, Ring-necked Duck, Common Egret, Black-billed Cuckoo, Parula Warbler, Least Flycatcher, and Veery, to name a few. Blincoe had already moved away to Dayton, Ohio, before his *Auk* article appeared; Bardstown has had no prominent ornithologist to continue the work begun so well by Beckham and carried on by Blincoe a generation later.

The Louisville chapter of the Kentucky Ornithological Society proudly bears the name *Beckham* Bird Club; for some years a local chapter at Madisonville was called the Leon Otley *Pindar* Chapter, but since the death of Mr. Brasher C. Bacon nothing further has been heard of the club. In his will Dr. Pindar left a good-sized sum of money to the Wilson Ornithological Society, of which, as said before, he was one of the founders, and a smaller sum to the Kentucky Ornithological Society. This latter bequest formed the basis of the Endowment Fund of the society, to which have been added the Life Memberships as they have been paid in. I still feel that some portion of the Kentucky Ornithological Society should bear permanently the name of Dr. L. Otley Pindar.

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FLAMMA CLARA MATURAE MEDICINAE KENTUCKIENSIS* †
(1750 - 1850)

By WILLARD ROUSE JILLSON, ScD.
President, Kentucky Historical Society

High honor and brilliant professional achievement mark the practice of medicine and surgery in early Kentucky. Looking backward now over more than two centuries, the several decades which closely followed the establishment of this Commonwealth in 1792 clearly stand apart, encircled by a bright aurora of conspicuous and widely acknowledged medical advance; a brief but glittering period wholly unmatched in its time, not only in America but throughout the civilized world. That such outstanding progress in the art of healing the diseased or maimed human body could and did occur in this remotely interior country, then hardly more than a partly settled outpost of American culture in the West, has not failed to engage time and again the thoughtful attention of those of philosophical mind in this and many other lands. Intensely romantic, the factual narrating of those closely succeeding, epoch-marking episodes of medical and surgical progress is, in its essentials, little more than the grouped life stories of a few men of genius, whose God-given talents and specialized training were singly addressed to the alleviation of the suffering of mankind!

Accordingly as we turn the pages of the beginning chapters of medicine in Kentucky, we find ourselves principally concerned with the personal character, original preception, and professional ability of those whose mission in life it was to step boldly in emergency into the unknown, and by successful example chart new coures of practice for their contemporaries and successors through all time to come. In this brief retrospective glimpse we shall also see that it was not the first intrepid, leather- stockinged physicians or those inadequately trained who were to conspicuously achieve and thus while adding luster to the profession attain the bright laurels of personal fame. It was rather a select few of those who came afterwards, when the log-walled station and stockade had become a village or a town and the educational facilities had improved to approximate or exceed those of the Atlantic seaboard, that time, circumstance, and brotherly love made the truly

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* Liberally translated: BRIGHT FLAME OF EARLY MEDICAL PRACTICE IN KENTUCKY. An address delivered before the Louisville Chapter, Student American Medical Assocition. General Hospital, Louisville, Kentucky, May 13, 1952.

great physician. In this unchallengeable fact, those of you who now look forward to some quick and easy and profitable solution of the Hippocratian equation of life may well find food for thought!

Transylvania Medical College

Kentucky was broadly traversed by American Colonials for thirty-five years or more prior to the actual settlement of Harrodsburg in 1774. Among the early explorers was a then well known Virginia physician and gentleman surveyor, Dr. Thomas Walker, who entered this State through the Cumberland Gap—which he named—in 1750. After skirting the Bluegrass region, but never seeing it, he made his way back to the East, only to return the following year and do a brief reconnaissance of portions of the Dicks and Kentucky river valleys. He left no medical record touching that part of the Commonwealth he explored. In 1775 a Dr. Hart settled at Harrodsburg and became, as a matter of fact, Kentucky's first practicing physician, but his medical activities were either so light or routine as to have produced little if any impression on that early community. Other physicians and surgeons of course, and as the years passed a good many, followed these medical pioneers, but in most instances their names, deeds, and places of residence have been enveloped by the growing obscurity of the years and the reward for their services to mankind, exemplary as it probably was, has been oblivion.

At the turn of the century, however, a new day was dawning for the medical profession in Kentucky. A full score of years previously —in 1780—the Commonwealth of Virginia allotted eight thousand acres of escheated lands within the County of Kentucke to the custody of a group of thirteen trustees "for the purposes of establishing a public school or seminary of learning.' Three years later twelve thousand acres of additional escheated lands were given by the General Assembly of the mother Commonwealth to the prospective school in the "district of Kentucky" now for the first time described as *Transylvania Seminary*. In 1789 this primitive school, having already opened its doors to students, was moved from the vicinity of Danville to Lexington where it acquired the town property now known as Gratz Park, a fine library, and expanding scholastic stature under the leadership of a number of serious men including the Reverend Harry Toulmin and the Reverend James Moore.

Late in 1798 the General Assembly of Kentucky moved to unite the separately established and competitive *Kentucky Academy*, a Presbyterian school of good standing, with the older seminary, and by Act created the *Transylvania University*. Early in 1799 the board of trustees of this new educational institution met and created "The Medical Department" or "College of Transylvania." With the renowned Dr. Samuel Brown installed as professor of Chemistry, Anatomy and Surgery and Dr. Frederick Ridgely seated in the chair of Materia Medica, Midwifery, and Practice of Physic, the *Transylvania Medical College,* as it was called, was off to a very good start, the *first* medical school west of the Alleghenies and the second to be established in the United States. At this time, it may be said with some pardonable pride, that Kentucky, the fifteenth State in the Union, was only seven years old!

During the quarter of a century that followed, the *Transylvania Medical College* steadily grew and prospered. As her fame spread, increasing numbers of students came to her lecture halls from the South, the West, and the North as well as from Kentucky. The faculty from time to time changed and broadened with the appointment of Dr. James Fishback, Theory and Practice of Medicine; Dr. James Overton, Materia Medica and Botany; Dr. Benjamin W. Dudley, Anatomy and Surgery; Dr. William H. Richardson, Obstetrics; and Dr. James Blythe, Acting President, Chemistry. In 1809 Lexington witnessed the granting by Transylvania University of its first degree of Doctor of Medicine to one of its own young men, John Lawson McCullough.

In 1817 a partial reorganization of the faculty brought to Transylvania the erudite and talented Kentuckian, Dr. Daniel Drake, as professor of Materia Medica and Medical Botany. Shortly after Dr. Horace Holly became President of the University—in 1819—he brought the versatile, many-sided Dr. Charles Caldwell from the University of Pennsylvania to fill the chair of Medicine and Clinical Practice, and with a medical library selected in Europe upon which some $30,000 or more had been spent, *Transylvania University* fairly faced the western world as a leader of academic, legal, and medical education and culture. During the 1820's and 1830's an average of some 200 or more students matriculated yearly in the Medical Department of *Transylvania University* alone, while during the entire period of its existence (1798-1855) it has been estimated that a total of nearly 6,500 students attended its classes and lectures and that about 1,850 were regularly graduated with official diplomas. During the period 1839-40 a new Medical Hall, much resermbling Morrison College, was built and occupied. It was destroyed by fire in 1863. With many new medical schools springing up over the country during these years, particularly in Cincinnati and Louisville, these registration and graduation figures speak in no uncertain terms as to the professional charatcer of the *Transylvania Medical College* and the preferential regard with which it was held throughout the Western Country.

Surgical Triumphs

The story of early surgery in Kentucky is one made notable by thrilling achievement and success, the ultimate effect of which, being at base scientific, was to open and standardize certain new operative procedures throughout the civilized world. Outstanding among not a few well qualified surgeons of this period, one recalls immediately a trio of that time—Dr. Walter Brashear, Dr. Ephraim McDowell, and Dr. Benjamin W. Dudley whose record, if it has been equaled, has certainly never been surpassed.

Brashear. Dr. Brashear, a man of great talent, courage, and penetration was born in Maryland in 1776. His father, Ignatius Brashear, removed his family to Kentucky and settled in Bullitt County in the vicinity of the Salt Works near Shepherdsville in 1784 where he shortly became well known as a daring and successful Indian fighter. Walter, the seventh son, early exhibited precocity, and at the conclusion of his elementary studies was sent to Transylvania University where he attained high rank as a Latin scholar. After completing his arts education he read medicine and attended the lectures of Dr. Frederick Ridgely in the Medical School for two years. Then he went east to Philadelphia where at the University of Pennsylvania he attended the classes of Drs. Barton, Physick, and Rush, the leading medical instructors of their time in America.

After a year in Pennsylvania, Brashear, still quite young and being possessed of a restless disposition with a desire to see something of the world, shipped to China as the surgeon of an American merchantman engaged in the Oriental trade. While in port there he was besought to attend the wife of a dignitary of the Court. He found the woman to be suffering from a cancerous breast. This he removed, after which her health greatly improved. During her early convalesence, however, he was held a prisoner for several days in the palace subject to being beheaded, as he was politely informed, if she did not promptly recover.

Returning in due course to the United States he at length began active practice in the vicinity of his old home in Kentucky. In 1806, while thus engaged, fame of the first order, which he seemed ever afterward to but lightly esteem, came to him suddenly and entirely unannounced. During August of this year he was called to Bardstown to attend a mulatto boy, seventeen years old, a slave at St.

Joseph's College, who was suffering greatly from a complex fracture of the thigh bone coupled with deep bruising and laceration of the muscular parts of the entire leg. Without precedent, anesthetic or trained operative assistants, but with the aid of two local physicians, Dr. Burr Harrison and Dr. John Goodtill, he had the courage to amputate the leg of this youth at the hip joint. Moving with great dexterity he cut the thigh at its middle third, tied all blood vessels, disariculated the femur at its socket and closed the broad, gaping wound.

In good time the brave boy completely recovered and in fact lived out a long and useful life. This emergency operation, one of the very greatest and most advanced of its time not only in Kentucky and America but the entire world—was broadly pronounced an unqualified success. Great renown then came to Dr. Brashear, and among numerous offers was one of the "Chair of Surgery" in the Academy of Science at Paris, France. To all of these he turned a deaf ear, giving his entire attention to his practice which grew apace. Restless again, though active, he removed to the State of Louisiana where within a few years a broadening appreciation of his professional talents and abilities secured for him political recognition resulting in his election to the United States Senate from that State. At the advanced age of 84 years, on October 23, 1860, he died and was interred in the state of his adoption, widely admired there and in Kentucky where his successful amputation of the leg at the hip-joint, when he was but thirty years old, had made history and etched the name of Walter Brashear high on the scroll of national surgical fame.

McDowell. During the first decade of the nineteenth century surgical partcice and academic dictum adjured major openings of the closed cavities of the body. Immediate or closely following death of the patient was held to be the inevitable result of such action. Surgical savants such as Dr. Rush in the Medical College of the University of Pennsylanvia laid this rule down as basic, and persons with internal organic growths and diseases, particularly women with ovarian tumors, were regarded as beyond the aid of surgery and were allowed to linger on beds of interminable and increasing pain and suffering until death, welcome as an angel, came and gave them rest.

At this time there lived in Danville, Kentucky, a physician—Dr. Ephraim McDowell—who was enjoying a modestly good practice chiefly as a surgeon, though he was only a little past his middle thirties He had been born in Virginia in 1771 and at twelve years of age had accompanied his father, Judge Samuel McDowell, when he removed his family to Kentucky to act as Commissioner of the Court to settle land claims in the District. Young McDowell, favored by modest affluence, received a reasonably good elementary and preparatory education at Danville and in 1789, at the age of eighteen, was sent East to become a medical student for two or three years under Dr. Alexander Humphreys at Staunton, Virginia. Office studies of this character under a well known preceptor in active practice was a widely acepted method of securing the basic training in medicine at that time. When this work was completed in 1792, McDowell journeyed overseas to the University of Edinburgh where, while attending formal lectures, he continued his tudent work under the preceptorship of Dr. John Bell, a widely known and very successful surgeon. In the spring of 1795 Dr. McDowell returned to Danville, Kentucky, and at the age of thirty married Sarah, one of the daughters of Isaac Shelby, the first Governor of the Commonwealth.

In 1809 he performed in his residence in Danville, now a State and a National Shrine, the first successful operation to remove an ovarian tumor. His patient was Mrs. Jane Todd Crawford, a middle-aged woman with children, of a good family residing in Green County. He was called in consultation by her local physicians who were of the opinion that she was somewhat advanced in pregnancy with twins. After a careful examination Dr. McDowell announced to the woman and her attending physicians that she was not pregnant, but was possessed of a large ovarian growth which if not soon removed would result in greatly increased suffering and death. He offered her as an alternative an experimental operation which he advised was widely frowned upon by the best minds in surgery but might be successful. She quickly assented, rode horseback to Danville, where, after a short rest, on Christmas Day in a small, low-ceilinged upstairs room of the house on an ordinary table with the assistance of his nephew, Dr. James McDowell, he made the dreaded abdominal incision and removed a tumor-infested ovary weighing in excess of twenty pounds, Her recovery was rapid and complete and she lived, enjoying good health, for 32 years thereafter, dying finally at the age of seventy-eight on March 30, 1841.

Careless of temporal or posthumous fame, Dr. Ephraim McDowell kept few if any surgical case notes and the number of ovariotomies that he performed will always remain in question, but the probability is that they numbered upwards of fourteen or fifteen, perhaps more, and of these about 75 or 80 per cent were successful, in that the patient lived and was returned to normal health. This continuing operative feat, at first disbelived by many leading American and European surgeons, at length became accepted and in succeeding years was adopted as rigorous but standard practice for diseased ovaries. One hundred and twenty-two years have now passed since the death of Dr. McDowell of "a fever" on June 25, 1830. Time has long since made it quite apparent that exceptional training and great courage fitted this naturally adept Central Kentucky surgeon for his monumental task, the sucessful completion of which has not only assured him a deserved immortality but inscribed his name as one of the greatest in the history of American surgery.

Dudley. Third in the group of really great surgeons during the first half of the nineteenth century in Kentucky was Benjamin Winslow Dudley, who was born in Spottsylvania County, Virginia, in 1785. He was brought to Central Kentucky when about a year old and, except for those periods early in life when he was pursuing his medical education abroad, Lexington and its immediate vicinity was his lifetmie home. His father, the Rev. Ambose Dudley, was a Baptist minister of small estate but excellent standing in the community. As a result the boy Benjamin did well to avail himself of what limited elementary and preparatory education Lexington afforded in those times. Though he had no knowledge of either Latin or Greek, at the age of fifteen, shortly after the organization of the Medical School of Transylvania University, he became a student of Dr. Frederick Ridgely, a very outstanding physician and teacher, with a large practice in Lexington and Fayette County. In this manner he learned the elements of medicine and acquired not a little bedside experience as he time and again accompanied his preceptor during visits to ailing clients.

In 1804 Dudley, then turning nineteen years of age, went East to attend the medical lectures at the University of Pennsylvania where among others he met John Esten Cooke, Daniel Drake, and William H. Richardson, students then who were destined within a few short years to be his colleagues in medical practice and teaching, sometimes harmoniously, sometimes otherwise, in Lexington, Louisville, and Cincinnati. During the long lecture interval of 1805—from April to October—while at home he began his practice with Dr. Fishback, a widely respected and active physician in Lexington. In 1806 he received his degree of M.D. from the University of Pennsylvania and returned to Lexington to practice. At length, feeling a deficiency in experimental surgical work and desiring additional medical instruction of advanced character, he went to Europe and spent four years in the hosptials and dissecting rooms of Paris and London. Here he gained the intimtae knowledge of anatomy, surgery, and disease that at once stamped him, upon his return to Lexington in 1814, as thoroughly competent. Changed now was his attitude toward his chosen profession. Conscious of his talents, ability, and superiority he moved into his practice of surgery with indefatigable energy and immediate success.

In 1817 Dr. Dudley became professor of Anatomy and Surgery at the Medical School of Transylvania. As he taught, his practice grew, marked by a constant stream of successes which soon set him apart as a national figure in the field of surgery. Resisting with firm determination many offers to go elsewhere he remained at Transylvania until 1850, the greatest teacher of medicine and surgery in this famed Medical College. He died in Lexington in his 85th year on January 20, 1870. After Dr. McDowell's retirement in Danville in 1825, Dr. Dudley became indisputably recognized as the leader of surgery in the entire Mississippi Valley. Though unlike Drs. Brashear and McDowell he left no important original contribution to his profession, he had earned a most enviable reputation as a great teacher of medicine and a great practicing surgeon. No small part of the fame of the Medical School of Transylvania University rests squarely on the teaching and operating record of Dr. Benjamin W. Dudley. His work as a practitionier in the field of Lithotomy alone was of the very first order; he had the unsurpassable record of 225 operations for stone in the bladder and only three deaths. Truly this man stood shoulder to shoulder with the great masters of surgery of his day!

Medicine

Drake. No one may write the history of medicine during early Kentucky without some extended account of the life activities and achievements of Dr. Daniel Drake who was and still remains, the inimitable genius of his day. Physician, teacher, civic leader, philosopher, and writer, he was withal one of the few to whom it is given the opportunity to blaze broad, new trails of professional thought and practice. Born in New Jersey in 1785 he was brought to Kentucky when he was two and a half years old. His father, Isaac Drake, and his mother, who before her marriage had been Elizabeth Shotwell of the Society of Friends, chose the Ohio River flatboat route to the Southwest, as did so many others to their sorrow before General Anthony Wayne silenced the warlike northern Indians at the battle of Fallen Timbers in 1794. Disembarking at old Limestone, now Maysville, they moved inland some twelve miles, cleared land, built a one-door, one-window log cabin and settled among a scattering of other early pioneers of northern Kentucky now known as Mayslick. Here on the main road of travel—usually afoot or horseback—from the Ohio to Lexington and the central part of the State, Drake passed his early boyhood. Of formal elementary schooling he had little if any, but at home he learned early and with great competence to spell, read, and write. In arithmetic he mastered fractions and decimals, but of grammar, history, and geography he acquired nothing ,for the simple reason it was not available.

When he reached the age of 15 years his father, having attained to some substance as the boy grew up, desired him to be trained as a physician. Accordingly he was sent to Cincinnati, a sprawling settlement of less than 1,000 souls built around old Fort Washington, and apprenticed to Dr. William Goforth, Surgeon General of the First Division of Ohio Militia. Indefatigable physically and mentally, Drake became a real and valuable assistant to Dr. Goforth, who after five years of preceptorship on August 1, 1805, convinced he could not further greatly aid the youth, issued him a curious "homemade" diploma of competence in medicine. With it, Dr. Drake, the ambitious, unstymiable young man from Kentucky—by his own statement—practiced to an ever widening circle of clients in Cincinnati, some of whom like William Henry Harrison were exceedingly influential, for eleven years!

A great man and a great intellect, Drake was a leader of Western thought and action before he was thirty and has in all seriousness been called "the Dr. Franklin of the West." Self-educated, a born writer with a free, lucid, and readable style, an observer and recorder of every kind of natural phenomena, particularly as it touched the physical ailments of man, he produced while a very young physician two books: *Notices Concerning Cincinnati, Topography, Climate and Diseases*: 1810, and *Picture of Cincinnati*: 1815. The eyes of all seaboard America were on the West, and these books quickly "selling out" in edition, made for him a national reputation. He became an intellectual personality in the East as well as the West. In 1816 when he reached the age of thirty-one, the University of Pennsylvania, where he had spent some time at lectures in the Medical School, assured of his talents, achievements, and standing, held a special Commeencement and awarded him the degree of Doctor of Medicine. A year later upon invitation from Dr. Benjamin W. Dudley, he joined the faculty of the Medical School of Transylvania University and from this time on for the remainder of his life was almost continuously engaged in medical teaching in Lexington, Cincinnati, and Louisville. Though he often saw the serpent's head of jealousy among his colleagues and on several occasions experienced the rough malevolence of open professional hostility, he was in the main warmly regarded and twice upon returning to Cincinnati, where he had founded in his earlier days the Medical

College of Ohio, and wrote that choice and now rare *Western Journal of the Medical and Physical Sciences* (1827-38), he was the recipient of tremendous popular ovations that stand alone in the history of American medicine.

His great work, *The Principal Diseases of the Interior Valley of North America,* begun in 1822, did not appear in print until two years before his death which occurred in 1852. Issued in two large volumes it spread a wealth of detail in support of the thesis, then new in medicine, that malarial and numerous other ailments are more or less geographically controlled. A remarkable advance at that time in medical philosophy, it might today be described as an ecology of some human diseases. Dr. Otto Juettner of Cincinnati writing biographically of this remarkable Kentucky physician in 1909 held Dr. Drake to be: "The most liberal of all our benefactors, the most brilliant of her gifted sons, the one really great man she [Cincinnati] has produced. . . ." Dr. Garrison, in his *History of Medicine,* has styled Dr. Drake "The greatest physician of the West and one of the most picturesque figures in American medicine. . . . [He] was the first, after Hipocrates and Sydenham, to do much for medical geography, and has a unique position of his own in relation to the topography of disease."

In his deductions, perceptions, and philosophies involving medicine, Dr. Daniel Drake, a natural, magnetic, and highly intellectual leader, was far ahead of the mass thought and practice of his day and time. His contributions to medical literature and practice were many and important, and they possessed, for the most part, the freshness and the originality of true genius. A restless, inquiring, advanced intellect teamed and timed with unmeasured energy he was the marvelous, unduplicable product of early Kentucky, the dangers, the hardships, the far-flung forests and the new pulsing freedom of the West.

Louisville Medical School

During the late 1820's and 1830's, the definitive period of greatest growth and influence of the Department of Medicine of Transylvania University, changing economic conditions in Kentucky began to take effect causing Lexington, long known as the "Athens of tht West," to recede in regional importance, and Louisville to expand in population, trade, and finance. The rapid development of cheap long-distance transportation of passengers and freight on the Ohio River by steamboat marked this era and brought about a pronounced shift of merchandising, manufacturing, and business generally from the limestone uplands of central Kentucky in and about Lexington to the Ohio

River flood plains and adjacent lowlands of Louisville. Though Lexington exerted every effort, including the building of the first railroad of the West to Frankfort and the wharves there on the navigable Kentucky River, the movement , deep-seated in the steady expansion and growth of the Western Country, could not be stayed.

In 1835 the changing requirements of medical education in the United States found Lexington without a hospital for student practice, and the town's slender and for the most part affluent population afforded very slight and precarious, and sometimes wholly inadequate, means for dissection, anatomical and osteological study. Adequate classroom and laboratory facilities for students also did not exist at Transylvania, and a continuation of the time-honored method of "Doctor's Office" instruction promised only to lead eventually to lowered standards of education when campared to other, highly competitive schools in this country. While these insurmountable physical conditions were assuming serious proportions in Lexington, and being debated by the Transylvania Medical School faculty, forward-looking citizens in the bustling town at the Falls of the Ohio had induced the Legislature of Kentucky in 1833 to pass an Act chartering the *Medical Institute of Louisville.* In the spring of 1837 at a town meeting held to discuss the Medical Institute and its importance, a resolution was adopted affirming that "there ought to be a college in Louisville" with a "Medical Department," and that it was expedient that the Mayor and the City Council should take steps immediately to endow this proposed educational institution.

Little time was lost. A grant of land bounded by Eighth, Ninth, Chestnut, and Magazine streets was made to the officers of the Medical Institute, coupled with an appropriation of $50,000 of which $30,-00 was indicated to be used to erect a new building for the Institute and the balance to be expended for a library, an anatomical museum, and other necessary equipment. In April the board of the Medical Institute of Louisville met and accepted the municipal gift, and made plans to staff and open the Medical School. During the summer six professorships were created and filled as follows: Dr. Henry Miller, Obstetrics; Dr. Jedediah Cobb, Anatomy; Dr. Joshua Barker Flint, Cooke, Theory and Practice; and Dr. Lunsford P. Yandell, Chemistry and, later, Materia Medica. These appointments signalized that the break had been made with Transylvania University; its supremely long undisputed supremacy in the medical field in Kentucky now stood at the crossroads of public opinion awaiting the verdict of Time.

That first year of 1837-38, the new Medical School at Louisville had 80 students of differing grades—certainly a fair and hopeful showing.

Of these, 27 received their M.D. degree in the following spring. At the same time Transylvania University, having filled the vacancies in its medical faculty by taking Dr. John Eberle and Dr. Jedediah Cobb from the staff of the Ohio Medical College in Cincinnati, registered 230 students in its Medical Department, which was only about 12 less than the preceding class. In 1832 the new Medical College building in Louisville was built and occupied and therewith the registration of the Institute increased to 120. During the summer of 1839 the Cincinnati Medical College, unable to meet the growing competition in Kentucky, closed, and Dr. Daniel Drake, its founder and erstwhile president, was elected professor of Clinical Medicine and Pathological Anatomy in the Louisville Medical Institute. The bringing of Dr. Drake, one of the most experienced and able teachers in the Ohio Valley, to Louisville, made it necessary to raise the tuition of the Medical Institute above those of all competing schools, but in spite of this, so great was the reputation and influence of Dr. Drake in the medical field that the registration actually increased to 205 in the fall of this, the third, year.

At the end of this session in the spring of 1840, Dr. Flint resigned and was succeeded in the Chair of Surgery by Dr. Samuel D. Gross, one of the famous surgeons of the western world, a very great teacher and a well known writer of medical text. In succeeding years the registration continued to rise rather steadily until it reached 347 in 1845. During the winter of this year, the General Assembly of Kentucky granted a charter to the University of Louisville and by the provisions of this Act the Medical Institute, now recognized as a very worth while and going institution, was absorbed and constituted as its Medical Department. At the mid-century mark—1850—the youthful Department of Medicine of the University of Louisville was brilliantly staffed, adequately housed and equipped. With a registration of 376 this "Medical School,' as it had already come to be called, had amply justified the hopes of its most optimistic founders, and as then broadly organized with only such changes and enlargements of faculty and intensification of teaching and practice methods as the years have proscribed, it has extended its remarkable record of high scholarship coupled with marked professional and community service down through the alternating troublous and peaceful epochs of the past century to this very day.

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FOUR THOUSAND AND FIFTY YEARS OF MATHEMATICS

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Introduction

Square brackets indicate references listed.

Square brackets with date indicate University Catalogs.

Most dates are approximate.

[0] indicates information from Dr. H. H. Downing.

This paper, written by invitation, must contain only brief reference to many interesting facts in the development of a department.

Omissions are at the discretion of the author. Miss Mary Hester Cooper, University Archivist, and her assistants, have been most helpful in locating and verifying particular references. For this interest and co-operation the author expresses his appreciation.

Problem: To trisect any angle

This classic, by far the easiest to comprehend of the four famous elementary problems left by the Greeks, [1], has been popular among the mathematically uninitiated for two and a half millenniums. It has commanded the attention of some famous mathematicians, too [2]. Hippias invented the quadratrix (c 425 BC) to present what was probably the first solution to this perplexing proposition of a curious Greek when he found that his curve could be used to separate any angle into any number of equal or unequal parts [3]. About this same time Archytas was using a peculiar topological surface to solve another of the famous four—the duplication of the cube. He was also busy building a wooden flying duck and a baby's rattle which drew comment from Aristotle [4]. But, back to our trisection.

It would be another two hundred years before Archimedes produced his spiral to solve the problem [1 p. 89], and two thousand years before Pascal (father of Blaise) developed the conchoid of a circle, the limacon, as a trisectrix. Pascal was to pattern his development after Nicomedes (c 240 BC) who invented the conchoid.

It is Nicomedes who interests us now because his developments were brought forth at a time, which, to us, is approximately the midpoint of mathematical history. Little or nothing is known about Nicomedes, he being remember solely throughout mathematical literature for the conchoid. Two thousand years pass before he is mentioned in the first mathematics book authored by University of Kentucky mathematicians [5] and this reference would occur, to us at this date, roughly at the midpoint of the entire history of the University.

This same problem, solved so many times and in so many ways, even perhaps as Euclid intended [6], would bring smarting reprimands to a young University instructor, from an irate, but not insipient, would be solver. An evaluation of a laborous struggle, made after lengthy study and deliberation of this even more lengthy but improbable solution, submitted for acceptance, brought a little thank you note which indicated that the writer had not been made vapid but that he had been brought to believe the mathematicians insidious.

Dear Mr. Downing, [0]

I am sure that the solution which I submitted recently is correct and nothing you have said has altered my opinion. It so happens that I do not belong to that click of mathematicians and no matter how correct and ingenious my work is, it would never be recognized. I expect to see my solution in print soon, in one of the best journals. But, I do not expect to see it published under my name.

With disgust and some cognizance of the strong recognition union you mathematicians have, I am

Truly yours,
(signed)

This chiding note of antipathy, wholly lacking predilection and written to predicate negative appreciation of a superb report came from a tax payer following his request that his work be duly checked and recorded. He, yet unable to slough his mathematical incipiency, had finally solved the famous problem which had left the most able mathematicians baffled for centuries, and he would not be derided.

The "solver" might have been informed that the solution to this problem was no longer cloaked in secrecy but had been available for centuries, that Nicomedes (c 240 BC) (who was classified as a minor geometer) had supplied the mussel-shaped curve, the conchoid, to perfom trisections [7] and that more than 250 years ago the trammel was devised for the special purpose of trisecting the angle, any angle [8]; and furthermore, the process curve with full explanation could be found in Boyd, Davis, and Rees [5]. But, this was not the reply. Showing the becoming intolerable disgust and cruel impatience which any informed mathematician would not allay when confronted with such a loathsome request for one to be vested with enduring fame, Dr. Boyd handed the proposed solution, which in fact was an excellent approximation, to a young instructor with these words, "Here, Mr. Downing, determine what's wrong with this and formulate a brief, and if necessary, tactless reply which will discourage extensive, in fact, additional correspondence." Thus began an assignment which could have placed a young man, a new instructor in mathematics in an embarrassing perplexity. But such was not the case, for, another young man, Dr. P. P. Boyd, Professor and Head of a small department of mathematics and astronomy meant what he had said. Also, he was to become Dean of the College.

But, we are ahead of ourselves. This conversation began roughtly a half century after a decade of incubation of a department of uncertain parentage and a half century prior to a critical but affectionate evaluation of a century of service. Be this embyronic period of the existence of the mathematics department one of growth and development describable as desirable, objectionable, theoretical, pragmatic, stagnant, intrepid, vascillating, perhaps another century will be needed before pointed classification can be set down with reasonable tranquility.

Let us dwell briefly on the status of mathematics in general that we may better orient the incubation period of the first half century of unrelenting efforts to establish a reputable institution.

Before Nicomedes, and Some After

The Sumerians made extensive use of copper and were proud carftsmen in their skillful handling of gold and silver. Their number system was positional, to the base 60 [90]. The earliest wheels and wheeled carts are found among the fragmentary relics of this long since enslaved but unfasted civilization. Clay tables were used on which have been found many types of mathematical computations. The most pretentious of these are attributed to the Babylonians [10] who seemed to know the Pythagorean Theorem in its full generality [11] and who supplied, at least a thousand years before the Pythagoreans, tables of Pythagorean triplets, all these to the base 60. The Hindus were to develop the base 10, wrongly called the Arabic numerals, this about 200 AD. The zero had been kicked around in the form ⪥ by the Babylonians; would be used in the form o (the omicron) by Ptolemy (c 130 AD), and in the form of a dot as a separator or position marker, to emerge in India (c 876 AD) definitely as the zero we know today, the big "goose egg" [12].

One of the Pythagoreans (c 500 BC) was sentenced to death for divulging their discovery that $\sqrt{2}$ is irrational [3], Democritus (c 400 BC) had anticipated Archimedes with the infinitesimal calculus by a couple of hundred years [14], Cavarlieri (c 1635) by this time ten fold, and Newton and Leibniz (who first published in 1682) by a few more years. The Pascal triangle was known to the Chinese (by c 1300) [15] by some other name, Taylor's special series would continue to be attrbiuted to Maclaurin [16], Cramer (c 1750) was destined to popularize a rule, which originated with the Chinese (c 1100 BC), was given by Leibniz (1693) [2 p. 326] and was to grow into the determinant as known today through the efforts of Jacobi [17] just a few short years (1850) before the founding of a Department of Mathematics and Astronomy of the University of Kentucky. At 55, Gauss was to complete some of his best work for which he is fully credited [18] despite the simultaneous developments by Bolyai and Lobachevski [19]. All three were probably familiar with the work of Saccheri [20] before their development of a disputed theory, non-Euclidean Geometry, which Gauss, because of his standing, was hesitant to announce. The findings of these mathematicians were to be the first real challenge to Euclid. Their denunciation of that much disliked postulate 5 would be long in print (some twenty years) before the University of Kentucky was established and would furnish a growing department with part of its first upper division-graduate work. The 1637 work of Descartes [21], published in French and Latin, was to be accepted as basic to the calculus and would furnish the incentive for the Department's first text, previously mentioned [5].

1865, Before and After

Cardan had stolen the solution of the cubic from Tartaglia [22] 300 years past, but the characteristics of π were still a mystery and would remain so until the second decade of the University's history when in 1882 F. Lindeman would show that π is transcendental [23]. Pi had suffered long tolerance and had appeared as three "about" in the Old Testament [24] and in the Rhind papyrus as $(\frac{4}{3})^4 = 3.1604$. Archimedes bounded it by 223/71 and 22/7, and the Chinese (c 480) gave it as $355/113 = 3.1415929$. About 1660, π appeared in the interesting but unexciting forms

$$\frac{\pi}{2} = \frac{2 \cdot 2 \cdot 4 \cdot 4 \cdot 6 \cdot 6 \cdot 8 \cdot 8 \cdot 10 \cdots}{1 \cdot 3 \cdot 3 \cdot 5 \cdot 5 \cdot 7 \cdot 7 \cdot 9 \cdot 9 \cdots},$$

$$\frac{4}{\pi} = 1 + 1^2 \Big/ \overline{2 + 3^2} \Big/ \overline{2 + 5^2} \Big/ \overline{2 +}$$

$$\frac{\pi}{4} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \cdots$$

Just prior to the opening of the University of Kentucky, π had been computed to 400 decimal places in the hope of discovering a repetitive pattern among the digits but this was not to be. A decade later, Shanks (1873) would present π to 707 places only to have an error in the 528th position [1 p.95] and in the fourth decade of the school's existence Buffon's (1760) famous needles problem would be used by Lazzerini (1901) for 3408 tosses to obtain $\pi = 3.1415929$, "an error (? ?) of only .0000003" [25]. Renewed interest in the statistical behavior of the digits of π would cause computation undreamed of during the early days of the University of Kentucky. Pi would be computed to 10,000 places [27] in 1 hour and 40 minutes, this almost at the end of our first century of UK life (1959) and certainly far removed from 1865; however, by the end of the first century the department which commands our attention is to have an electronic computer capable of carrying out such astounding computational feats, once instructed to do so, in language it can understand, and with someone to push the start button. Let us return to our date of interest.

1865 - 1875

That war was still as fresh in the minds of the students and faculty as it remains so with some today. Lincoln had given his watch [27-28], a cheap Wm. Ellery key wind Waltham movement, to Dennis Shanks. The streets of Lexington were for horses and an occasional leg powered highwheeler. Henry H. White was Professor of Mathematics and Astronomy as well as Librarian to the University, a school which would mother both Transylvania and the University of Kentucky. In 1868 he would become one of its presiding officers, equivalent to a dean. In the same year, James Garrand White, who was to serve the future State University in many capacities, joined his father as Instructor of Mathematics and, from available information, H.H. White probably devoted his energies more to administration, apparently teaching no mathematics in UK's forerunner, the Agriculture and Mechanical College, after it was formed.

The next year James Garrand White became Adjunct Professor, and was to become (1875-1913) Professor and Head of the Department of Mathematics and Astronomy, then Dean, Acting President (1910-11), Business Agent and Vice-President from 1909 to 1913 at which time he would hang up his lantern.

The [1865] mathematics offering was excellent though there is little indication of the participants who indulged in a study of Towne's Algebra and Davies' Legendre's Geometry as freshmen, more plane geometry plus trigonometry and mensuration as sophomores, Loomis' Calculus and Snell's Olmsted's Mechanics as juniors, and, if they survived, Davies' Spherical Trigonometry and Snell's Olmsted's Astronomy in their senior year.

It is evident that the Mathematics Department, from the beginning, was (and still is) a service department. But in the formative years there seems to be no resentment, and attempts to discard the shackles of slavery were either abated or never belched sufficient clamor to be discernible. The Department consisted of one professor and not until 1900 is there an indication of faculty expansion. This is nothing to excite one's prejudices pertinent to teaching overload since the mathematics and in fact, all teaching loads must have negligible during the first two years. Records show [29] zero staff and zero enrollment in 1865 (the year in which we think we began) and 11 staff and zero enrollment for 1866. One instructor must have felt insecure (a description often applicable but suffering from overabuse). The enrollment for 1867 is tagged at 190 serviced by 10 staff. By 1875 these figures stood at 98 and 8 respectively, and by 1900 had skyrocketed to 309 and 43, with 34 receiving the various degrees, this 34 times the size of the first graduating class in 1869.

Tuition was set at thirty dollars per nine months for a mathematics student as well as for Agriculture and Mechanics and Commerce students whom the Department enrolled. Law students were gouged a little harder and Bible students studied free. This latter group was dealt a special courtesy, "to encourage preachers . . . poor and pious . . . ." They could obtain board for $1.50 per week, washing at $10.00 per year, fuel and lights for $8.00 per semester and must pay $5.00 to the janitors' fund. If a mathematics student associated himself with "The School of Practical Mechanics", the University Catalog [1870] records " . . . the object we have in view is to make it a school of practical instruction . . . and at the same time a means of support to the student and a source of revenue to the University." The following is an exhibit of educational services, research contracts of a bygone era, rendered by this department:

REPAIRS

22	2 Horse wagons
64	2 Horse plows
43	1 Horse plow

60 .... cultivators

. . .

1 machine for making brooms
5 Hay Rakes
5 Patent Improved Clothes-horses

Purposely, we do not list the details of reparis to carts, buggies, drays, and doubletrees. The entry "1 Bank Counter" could be the beginning of the University's Computing Center except that to the student of carpentry, it was but a sturdy, skirted table on stilts. Some mathematics students worked for the Horticulture Department which maintained its fruit and vegetable stall in the city market place where it sold "student cultivated produce, produce of an uncompensated labor system." It would be a quarter century [1899-1900] before this labor rate would be six cents to ten cents per hour. The students were to use the money as "they see proper," but received the staunch warning that, "No student should come to college expecting to maintain himself exclusively. At least $75 per year should be at (his) command."

In 1873 Hermite, better known for his contributions to matrix theory [30], proved that the number e is transcendental [31], and this same year Professor H. H. White, Mathematics and Astronomy, requested "permission of attending board meetings by faculty." Parking was a problem too, even though it must be another four years (1877) before the auto is invented [32]. (The U. S. has since produced more than 2200 different makes of automobiles. In name, every letter of the alphabet is represented, save x, the mathematicians' choice.)

From one note it appears that Dr. Patterson had withheld from his salary or had caused to be witheld from another's salary $14 for pasturage. If this seems ridiculous, then how must our juvenile bickering and petty political activities impress those self centered promoters of that modern generation a century hence, when, young and inexperienced, ignorant but careless, selfish and conceited though they be, they look back upon us with sympathy, love, and a prejudiced misunderstanding that for our lack of diligence they would be developed to an even greater degree of genital perfection.

1875 - 1900

This year (1875) as if the Greeks influenced a theorematic race, Aristides won the first Kentucky Derby. The Department, now 11 years old, was without electric lights and telephone service. 1876-77 brought a development of the telephone but only to the Boston vicinity and Edison made his first successful light bulb in 1879 [33]. The mathematics curriculum was changed but not drastically. "Plain" trigonometry was offered [1881] but seems to have disappeared from the catalog in 1882. Requirements were removed from the senior year offering [1886] and a full year of Practical Chemistry may be substituted for calculus for the A. B. in mathematics.

The Department also boasted "abundant facilities for field practice, with a full set of surveyor's instruments, are furnished to all who desire to learn the practice as well as the theory of surveying."

For a while Professor White (J. G., since there are three) shouldered the responsibility for physics but he dropped this obligation to Newbrough in 1889, the same year that saw Hollerith [34] push the father of our present day computers to manhood by maturing the babies of Babbage, the *difference engine* of 1822 and the "Analytical Engine" of 1833.

A university calender [1897] listing only five events, including Christmas and Thanksgiving may not enlighten one as to the important occasions in the lives of faculty and students but the 1896-97 entrance test in mathematics would, in the opinion of one who has witnessed many, many tests, reduce our present enrollment by big numbers if taken seriously today. Selections from this test indicate that the freshman of that year must have been possessed of not only ability and prehension but unlimited perserverance and patience. This conclusion is supported adequately by problem 2 below.

1. Find g. c. d. and l. c. m. of 899 and 961.
2. Simplify
$$2\,1/4 \times \frac{10\,3/4 - 4\,11/12}{6\,3/16 \times 7\,2/3} - \frac{3\,5/11}{1\,2/5 + 9\,1/11}$$
3. A and B can do a piece of work in $2\frac{1}{2}$ days, A and C in $3\frac{1}{8}$ days, B and C in $4\frac{1}{4}$ days. Required the time in which all these working together can do the work, and in which each can do the work alone.
4. Reduce 9 square chains, 11.25 square rods, to the decimal of an acre.

Other questions involve iron bars weighing 93 pounds for $3\frac{1}{3}' \times 3'' \times 2\frac{3}{4}''$ to compare with one of dimension $3\frac{1}{3}' \times 4'' \times 2\frac{1}{2}''$, grain production, and plastering.

The department is still a one man department but Professor Pence who, with his daughter Dr. Sallie E. Pence (to become Professor of

Mathematics and Astronomy), would serve the University for a record 100 years, had now been in charge of physics several semesters and thereby Professor White was accomodated.

Curriculum changes during this period (1875-1900) are insignificant. The [1899] catalog lists a staff, about ten of which have had halls named in their honor, White among these. Joseph Morton Davis, A.B., B.S., to be coauthor of Boyd, Davis, and Rees [5] became second assistant in the Academy. Entrance requirements for the freshman class were given as

> "A thorough knowledge of Arithmetic, of Algebra through Quadratic equations as presented in Wentworth's Higher Algebra, and of Plane Geometry as presented in books first and second of Beman and Smith's Geometry, is required for admission. . . ."

Astronomy is mentioned:

> "In this class the aim is to give to the students a knowledge, as accurate and as extensive as the time will allow, of the phenomena of the heavenly bodies and of their probable condition and history. No effort will be spared to make the study of this branch of science interesting and instructive."

Calculus was now to be begun second term of the sophomore year, one year behind our present schedule. Travel pay was of concern to the student since, if he were a county appointee he was given travel pay, tuition, matriculation and room rent free but was "charged $2.50 for use of the furniture . . . expected to provide *at his own expense*: . . . pillow-slips, . . . looking-glass, blacking-brush, hair brush, and clothes-broom." He must also travel to and from the University by the most expeditious route and present receipts for his expenditures, whereupon, at the end of the year he would be reimbursed, given money to return home, and be discharged.

A world shuffles across a century marker and a University is 35 years worn. Cantor had presented two of the most unexpected mathematical discoveries [35; 2 p. 275], a by-product of his unscrupulous search for the properties of the infinities, bringing forth ideas which, a half century later, would awaken the mathematical world from its pedagogical sypnosis and furnish crod for the insatiable appetite of the mathematically inept. Full of incompleteness yet complete with critics who had not believed it sound, neverthless, "sets" would be, incorrectly, that "new mathematics" at the turn of the University's first century.

1900 - 1914

The Department begins the new century with its first full time assistant, James R. Johnson, B. M. E. Formerly an assistant in shop-work and drawing, he now shared assignments with John A. Sharon who had begun as an assistant in English and Mathematics the previous year.

This year (1900-1901) finds William Snyder Webb an avid student in his ardent pursuit of the facts of physics, and later archaeology completing his work in mathematics, Captain of A Company Cadet Battalion, and a graduating senior, physics major. His mathematics was to earn for him, the severest of reprimands from an irritated commanding officer when, during World War I [0], Webb corrected errors in the gunnery tables by preering therefrom those unproductive entries.

Johnson, in 1901, becomes the Department's first assistant professor, while Sharon, now with the B. Ped., becomes a Fellow Assistant in English and Mathematics, and W. S. Webb, B.S., begins as a Fellow in Physics.

Theodore Tolman Jones, an affable scholar of Latin and Greek, and a mathematics major, began training for a lifetime of devoted loyalty to the University. As Fellow Assistant in Classics and Mathematics he was to rise to be Professor of Ancient Languages, Head of Department, Dean of Men, and, at the beginning of World War II, "too old to war", as he said, would answer his dean's plea for help in handling the hundreds of young men who were to be trained in mathematics under the ASTP program.

The year following Jones' appointment as Fellow finds Downing pleading for admission to the Academy. With youth, controlled vigor, an abundance of appreciated dry wit, an inherent belief in man and himself, and a logically compounded argument he was admitted—conditionally. Sometimes one has the feeling that he did well, but on other references it appears that he may have been forever on the dodge. He is carried under what is probably as many erroneously assigned names an any to enter our school. In

1905 he is H. H. Downing, State College of Kentucky, Corporal Co. D., Cadet Battalion.

1906 he is Harry Hardesty Downing, Civil Engineer, Lexington, Kentucky. Captain, Company A.

1907 Harold was used, Major 2nd Battalion.

1908 now Howard Hardesty Downing, B. C. E., Fellow assistant in Civil Engineering, Mathematics and Physical Education.

Back to Harold in 1910, he has answered to H. H. and, affectionately, to H square, since, for good reason. We shall return to Dr. Downing's accomplishments later.

Our interest now lies in closing out the first half century of the University's Department of Mathematics and Astronomy, a half century of no distinguished mathematical research, no books, no scholarly publications in scholarly journals, but fifty whole years of devotion to the implementation of a superior learning environment, loyalty to one's self, one's students and fellow colleagues, a spirit of co-operation and a seeming lack of distrust and anxious condemning adjudgication. A desire for less solicitous boredom prevailed. Even during times of a wildly oscillating economy the spirit was unmistakably exculpation rather than execration.

Freshman Downing knew Miss Martha Ripperdan White, daughter of James G. White, granddaughter of H. H. White. She became assistant in mathematics in 1904 and disappeared from the catalog in 1908, the year Downing became a civil engineer. Granville, a name in mathematical circles sufficient to identify positively one of the most successful calculus books ever written from the standpoint of its reign as a text, was published in 1904 and adopted for use at UK in 1906 when Joseph Morton Davis, A. B., B. S., left his academy duties to become J. Morton Davis, Assistant Professor of Mathematics. There was little change in the mathematics curriculum. The college catalog leaves little doubt that vociferous appeals for scholarship, increased funds, and particularly, a more grandiose school name were the objectives of those concerned for the school's future. And then it happened. The General Assembly of Kentucky authorized "State University" in 1908 and the catalog [1908 p8] used space to comment on state expansion and growth during the past period.

Certainly changes in the curriculum had happened during four decades, but indicated improvements were, if it can be said without admonition, to an extent scarcely obvious. Emphasis was on teaching, good teaching, and this, if executed, produces in the recipient, changes which accompany him throughout the short time of a life span. The quality of embedded ideas resulting from the creation of a learning environment is more reliably evaluated after the enactment of long and arduous application. After death, unhampered by pretentious make belief, only then is it possible to measure the effect of that which one has learned and whether or not he has continued to learn from the mistakes of others, from his own mistakes, enhanced by inborn curiosity.

For some reason Kentucky and Education seemed to be competing with Germany and Education, supposedly since German mathematicians had made recondite findings, its scientist were erudite as well as creative, and its manufacturing techniques merited emulation. But, except for the adoption of a few German mathematics texts at the graduate level and the teaching of a lot of mathematics uncovered and invented by the Germans, other indication of influence is not immediately revealed.

The information on summer school [1906] almost irritates one's innate curiosity concerning the number of letters the deans must have received. Today one would never find, in a university catalog.

"Many a dull or lazy student who has failed . . ." or a straight forward condemnation of

". . . American life and amid the insane pursuit of money . . ."

During this period the summer offering, under the tutelage of J. Morton Davis and T. T. Jones, consisted of mathematics, astronomy, English, Greek, Latin, French, German, Spanish, history, and Anglo Saxon. This team assures one that

> 'Last summer instruction was given in all these subjects and more than 4/5 of our students passed. . . .
> Fee for each subject, *in advance,* $7.50"

Elijah Latham Reese, B. C. E., who was to serve the University long and well and to retire to Florida while still young, became a Fellow assistant in mathematics and civil engineering, and T. J. Orr, a student assistant, this Downing's senior year (1908). State College, having become the State University, experienced the usual reorganization. It now had three schools, and pertinent to us, an expanded program in mathematics. Feeble by present calipers, so much so that perhaps one is inclined to measure the growth increment in lignes rather than by use of the pedagogical yardstick; nevertheless, the requirement of calculus for all engineers shackled many an engineer to his room at night, and in some cases, to the campus for an extra year. Thirty-five years later an engineering student was heard to remark, following his learning of the removal of sophomore English from the engineering requirements, "Good! I wish they'd remove this blamed calculus and maybe I'd have a chance to get out of this dadburned place."

Theory of Equations, Determinants, Differential Equations, and

History of Mathematics were also available in 1908, ". . . if desired by sufficient number of persons qualified to pursue them."

A major required 64 credit hours (1 credit then being equivalent to two in 1956) for the A.B., exclusive of military science and "physical training". The A. B. degree with any major required 5 years of Latin, without exception. As usual there is no outline of course of study for math students and no mention of majors.

By 1910 Fines's College Algebra was used for Theory of Determinants. Vector Analysis and Advanced Calculus were listed as available by demand. The catalog often carried assurances of a desire to serve, for example, "Other and more advanced courses in mathematics will be given varying from year to year to meet the needs of special students in mathematics, whether undergraduate or graduate" [1910].

Number Theory, Modern Analytical Geometry, Differential Geometry, and Higher Plane Curves were soon added to the student's choice and Sallie E. Pence became a freshman [1910 p. 222].

Mathematics is now (1912) among the 9 majors available to the student. Mathematics Ia, or Chemistry I, or Physics III and V are required for all A. B. students and prospective B. S. major must select his major by the beginning of the sophomore year. The teacher' course, offered by Professor Davis is "A Critical Review of the Mathematics of the High School, 2 hours per week, throughout the year". Professor White has just completed a year as Acting President, has obtained the services of Paul Prentice Boyd (a young Ph.D. from Cornell), returned to the vice presidency and assumed the additional duties as Dean of Men both of which he would retain until his death in 1913. Through his persistent efforts he saw his department(mathematics) and in fact the entire University become an organization possessed of the highest standards, revered for its leaders, hailed for its loyal and effective teachers, and supported for its maintenance of a scholarly atmosphere, and recognized for influence upon the fine young intellects of the Commonwealth. Before his reward for a lifetime of service to mankind he saw a college catalog which he had helped to say,

> ". . . must make up necessary undergraduate work. No bachelor of arts from any institution, however exalted, can become a candidate for the degree A. M. unless he has studied collegiate Latin in a satisfactory manner."

Added to this, one finds:

> "(One may) not become a candidate for the Ph.D. degree un-

less he has already a good reading knowledge of French, German and other languages. The degree is not for faithful work merely but for original and worthy investigations and the thesis must prove satisfactory to

(a) the major professor

(b) graduate school committee

(c) 2 or more independent specialists in 2 or more independent institutions of repute."

The first fifty years were stocked abundantly with plans, and changes, and tradition. This was 5 decades of growth, growing of an inexperienced faculty, growth of a curriculum, growth in housing facilities, all this culminating in a mammoth school when aligned with that zero enrollment in 1865.

The last of the first fifty found some with grief, grief for a lost servant. But man, despite his deeds, must move on, and Dr. White hung up his lantern, a short wick turned low. Death comes to a man; the institution remains alive. A new head, Dr. P. P. Boyd, a new course, Boyd's Geometric Transformations, five assistants and instructors in addition to Davis, Rees, and Downing, and the school bell continued to ring.

A carbon copy of old news was reread which reminded the weary that the long furtive shadow of the soldier would soon trod on the campus again. Fluctuations on the American market were now being felt as far away as Switzerland, where our economic barometer registered in a most painful way throughout the whole of the Swiss watch making industry [36]. Radio, although known since 1888 when Hertz developed Hertzian waves [37] (the same H. R. Hertz who wrote "Die Prinzipien der Merchanik (1894)) was blaring neither from the dormitory window nor from the student's shirt pocket. It would be another half dozen years and one world war before, in 1920, man was to listen to the first regular broadcast and declare that there must be a hidden gramophone somewhere. Hilbert, three years older than the University had published the *Grudlagen der Geometric* [2 p. 334], a work which was to advance the interest in geometry on our campus. Peano had given us, a few years earlier [38], the first axiomatic definition of number to lay the foundation for several courses which were to find their way into the graduate offering and finally into our lower division course of study, three decades later.

A new kind of pen, a ball point, had been invented about 1880 in South America but two world wars and a dozen small encounters would pass before students could write underwater. Two world wars from now students would sit (and sleep) in their classrooms undisturbed by a sonic boom which could shatter window panes about them while at the turn of our first half century many of the students had yet to see a plane and all run to the window when one flys over. (Teddy Roosevelt was almost dislodged from the precarious perch of an early plane on his introductory flight near the end of our first half century and the first flight from New York to California consumed 84 days.) Classical theory of numbers was no fraud, but abstract algebra was unborn [39]. The unpatentable claims based on the Huggeford jewel [40] were fraudulent but proofs of the impossibility of trisecting any angle under Euclidean regulations [41] were as correct and logical as mathematics.

Thus, while the crowd sang songs like "The Auto Rag", "Gasoline Gus and His Jitney Bus", the noiseless vacuum toothpick became popular, Mezger's automatic windshield replaced the goggles, the quip, "A guy who owns a second hand fliver is always trying to start something" got a big laugh, the 1914 Rauch and Lang Electric Auto was the town car of distinction [42], those trisections came in and the department members tried to analyze them honestly, answer promptly, and get ready for their first master's student. They had already graduated their first A. B.

But mathematics and mathematics students were not to receive the faculty's full energies, albeit near so. There must be letters from some with "D-" academic records in mathematics, divulging their arrogant bias while proclaiming their scornful contempt of the twosome, the mathematics and mathematics professors whom capable students must tolerate. Just as certain as Shakespeare had used two to's and questionable equality to produce a collection of words familiar even to the Shakespearean illiterate, there must exist that supercilious subset, uncultured, and mathematically unkempt. A mathematics professor has expressed the idea that, ". . . to survive in a college atmosphere among the insouciant one must be alert but unattentative; else mathematics, standing in ill repute with those for whom it was never meant but in whose chosen fields of study it is an absolute necessity, unknown to those who advise, will be but a lost art."

It is less ulcerous to weigh spansmodic attacks against mathematics on a cant hook of pious ignorance or conventional budgetary heresy. No one, a learned scholar in one field can be hopelessly ignorant in all others and before being hypercritical of what is to us illogical reactions by others it is good to remember that competent mathematicians are uncertain or in error even in their own field most of the time.

Perhaps Dr. Neville had known that it was Hooke [43] who invented the hair spring, and later the anchor escapement to give us the short swing pendulum. Being a scholar of Greek and Latin he knew of the early struggles with machinery and evidently had appraised John Harrison's contributions to man even though Newton believed Harrison's feat impossible. For these or some similar and justifiable reasons, Dr. Neville writes, toward the end of our first half century:

> "While no wise man will seek to disparage or unduly to exalt any branch of knowledge, it is not invideous to say that though the vast expansion of science during the wonderful nineteenth century has contributed enormoulsy to the comfort and glory of man, yet an immense majority in the civilized nations will continue to feel more interest in man and his doings than in mathematics and its properties, more in literature than in science, and more in the applications of science than in its principles and processes." [1907-08 p. 90]

The mathematicians of the day stood on the high side of the hill. When dealing with the mathematically inept they sat with their backs to a strong wall and learned where the windows were, less the multitude of small fires make intolerable smoke. It was FooChu who said, "Difference between brave man and coward is, brave man anticipates future with deep but unchasmal ponderability, coward runs, always."

From the early days of mathematics it was evident that the best mathematicians are seldom tyrannous. The accomplished need not be guilty of despotic abuse of authority, if in fact they have any. And only the unlearned carry small brief cases in order to appear large of stature. The University's mathematicians become aware of another fact during a short, effective 50 years. Mathematics is not a sport for spectators. A mathematician cannot be a coward but must indulge in mathematics and sometimes, its defense, even against the unscrupulous, the professed ignorant, the mathematically unclean. It was this philosophy which was to guide the Department to one of national recognition and international familiarity during the next half century.

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SOME COMPARATIVE BEHAVIOR STUDIES ON THREE GENERA OF SALAMANDERS

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A survey of the literature reveals little information pertaining to the behavior of the salamander genera *Eurycea, Desmognathus,* and *Pseudotriton* in reference to responses to gradients of light, pH, and soil moisture. This research was undertaken to increase our knowledge of these responses on a comparative basis in the above named genera.

The relative activity of related animals may be studied by comparative behavior responses. The animals chosen for this work, *Eurycea bislineata bislineata, Desmognathus fuscus fuscus, and Pseudotriton montanus diastictus* were selected because their habitats overlapped and there should be some factors of the environment common to all three. *Eurycea b. bislineata* is distributed over part of southern Canada, most of New England and south to Tennessee. *Desmognathus f. fuscus* has a similar distribution in that it is found over most of New England and extends into southern Alabama and Georgia. *Pseudotriton montanus diastictus* has a more restricted range, being found from southern Ohio into western Virginia, middle and eastern Kentucky and eastern Tennessee (Conant, 1958).

Eurycea b. bislineata is usually found beneath rocks and stones on wet soil. However, it may be found away from water or wet soil in drier situations. *Desmognathus f. fuscus* frequents the margins of streams and springs, leaf-filled trickles, and brooks, where it is constantly moist. Frequently, this salamander enters water, but it is essentially a terrestrial form. *Pseudotriton montanus diastictus* is perhaps a little less aquatic than *Pseudotriton m. montanus,* however, it is found in moist situations in or near small streams (Bishop, 1962).

Materials And Methods

Light Gradients: The comparative responses of *Eurycea b. bislineata, Desmognathus f. fuscus,* and *Pseudotriton montanus diastictus* to white lights of different strengths and to various monochromatic lights were studied by means of a cardboard box divided into two compartments by a partition. Three holes were cut in the bottom of the partition to permit the animals to pass freely from one side to the other. The floor of the entire box was covered uniformly with a layer of dry soil. Each compartment was covered with a piece of cardboard and the light source was placed just under the cover.

Table 1. Reactions of Salamanders to Light Gradient in Experimental Trough (30 Minute Tests)

No. of Feet From Light	Eurycea	Desmognathus	Pseudotriton
1	0	0	1
2	1	3	2
3	3	3	7
4	2	5	1
5	6	1	1
6	0	0	0
7	0	0	0
8	0	0	0

The two types of light gradients established were: (1) monochromatic light-darkness and (2) monochromatic light-white light. In the former gradient, monochromatic light was considered side "A" and darkness side "B". In the latter gradient, monochromatic light was side "A" and white light side "B". All of the light experiments were conducted in a darkened room where the temperature varied from 21.1 to 23.8 degrees Centigrade.

Both colored (red, blue, and green) and white bulbs were used. The colored bulbs were 7.5 watt Westinghouse bulbs. Each light was analyzed by means of a model 14 Cary Recording Spectrometer. The red wave length was from 6000-7000 angstroms, the blue wave length was from 4100-4700 angstroms and the green bulb emitted light in the estimated range of 3600-5400 angstroms. In the latter case, the bulb was a white one painted green and could not be accurately measured. The white Westinghouse bulbs were of two sizes: 7.5 watts (3 f.c.) and 25 watts (25 f.c.).

Eight light gradients were studied; for each gradient, thirty tests were conducted, one specimen of each of the three genera being the test animal in ten individual tests. Each test lasted for fifteen minutes. A total of 240 tests in the eight gradients comprised 60 hours of observation time. The salamanders had a choice between a light on one side of the box and darkness on the other side in the first five gradients. These gradients were as follows: Gradient 1, 25 f.c.-darkness; Gradient 2, 3 f.c.-darkness; Gradient 3, red-darkness; Gradient 4, blue-darkness; and Gradient 5, green-darkness. The other gradients were Gradient 6, 3 f.c. white light-red light; Gradient 7, 3 f.c. white light-blue light; and Gradient 8, 3 f.c. white light-green light. In the first five gradients, the salamanders were placed in the lighted side of the box and in the last three gradients half of the time in side "A" and half of the time in side "B". In this way the salamanders were initially exposed to both lights.

When a light-darkness gradient was used the time that elapsed from the beginning of a test until the animal crossed into darkness was called the "reaction time". The total time an animal stayed in side "A" and side "B" was carefully recorded. Whenever the animal passed from one side to another, this was referred to as a crossover and was noted and totaled at the end of a a test. At the end of a test, the animal was removed and placed in a terrarium. Animals to be tested were kept from all light until they were to be used. They were always handled with care so as to have them in a calm state. After an animal had been tested, it was not used again for at least one hour.

A second method of testing for reactions to light gradients was used for comparison purposes. A light gradient trough was constructed which was 8 feet in length, 4 and ½ inches in width and 4 inches in depth. The interior of the trough was lined with moist paper towels and observations were readily made by removing the top. A gooseneck lamp with a 25 watt bulb was used for the light source. A glass plate was used as a heat jacket between the light source and the experimental animal. The entire apparatus was located in a room of 22.2 degrees (average) Centigrade and total darkness. An individual salamander was placed in the trough for each test. Each test lasted for 30 minutes. Thirty six individual tests were run in this gradient; 12 for each genus studied.

Soil Moisture: The reactions of *Eurycea b. bislineata, Desmognathus f. fuscus* and *Pseudotriton montanus diastictus* to different soil moistures were studied. A glass terrarium 24 inches x 24 inches x 10 inches was divided into four compartments with a cardboard platform five inches square in the center. Each compartment was filled

Table 2. Reactions of Salamanders to the Moisture Concentration of the Soil (Twenty 20 Minute Tests Per Genus)

	Eurycea	Desmognathus	Pseudotriton
Animals in Soil Moisture Content of 20.9% and 33.9%	0	0	0
Animals in Soil Moisture Content of 55% and 57.1%	20	20	20

with a soil of pH 6.7 and varying amounts of moisture were added. The animals were placed on the cardboard platform and a cardboard lid was placed over the terrarium. At the end of 30 minutes the top was removed and the distribution of the animals noted.

The per cent of soil moisture was determined empirically by the addition of water which was added to each compartment of the terrarium and actual water content was calculated after the experiment from the soil taken from each compartment. Such samples were weighed, then dried for 24 hours, and reweighed, moisture content being computed as per cent of water lost to the weight of dry soil (Rosenthal, 1935).

Soil pH: The study of the reaction of *Eurycea b. bislineata, Desmognathus f. fuscus,* and *Pseudotriton montanus diastictus* to soil pH was observed by allowing the animals to choose between two soils of different pH. A glass terrarium was used in which a small cardboard partition one inch high separated the floor of the container into two sections, each containing a soil of different pH. Six holes were cut in the cardboard partition to allow the animals to pass from one side to another. The soil in one section had a pH of 6.3 and the other a soil which was pH 7.1.

Table 3. Reactions of Salamanders to Hydrogen-Iron Concentration of the Soil (Twenty 10 Minute Tests Per Genus)

	Eurycea	Desmognathus	Pseudotriton
Per Cent of Time in pH of 6.3	56%	56%	25%
Per Cent of Time in pH of 7.1	44%	44%	75%
Number of Crossovers	44	36	10

To determine the pH of the soils a Model 20 Coleman Electrometer pH meter was used. The procedure for finding the pH of a soil sample was essentially that of Reed and Cummings (1945) except that a ratio of 1:2.5 was used for soil-water ratio.

Twenty ten minute tests were performed on each species. For half of the tests the animals were placed in one section of the gradient and for half of the tests in the opposite section. No animals were used more than once during an hour. The number of crossovers, as well as the total time a salamander was in each of the parts of the gradient, were recorded.

Results And Discussion

Light: Research on salamander reactions to light have shown that most species tested were negatively photo-tactic (Reese, 1906; Pearse, 1910; Cole, 1922; Bishop, 1927; Vernberg, 1955; and Hutchinson, 1958). Results show that *Eurycea b. bislineata, Desmognathus f. fuscus,* and *Pseudotriton montanus diastictus* are negatively photo-tactic for some gradients and positively photo-tactic for others. In the first five gradients studied, where animals had to choose between light and darkness, the species varied in these reactions; *Eurycea b. bislineata* being negatively photo-tactic in response to red-darkness, blue-darkness, green darkness and a borderline case for being positively or negatively phototactic in 25 f.c.-darkness and 3 f.c.-darkness. It is interesting to note from Table 4 that the per cent of time *Eurycea b. bislineata* remained in the light was similar in all gradients. *Desmognathus f. fuscus* was negatively photo-tactic in red-darkness only; slightly positively photo-tactic in blue-darkness and definitely positively photo-tactic in the gradients of 25 f.c.-darkness, 3 f.c.-darkness and green-darkness.

Table 4. Reactions to Various Light Gradients
(Ten 15 Minute Tests Per Genus Per Gradient)

Gradient	Eurycea	Desmognathus	Pseudotriton
		Per Cent Time in Light	
25 FC—Darkness	48	53	69
3 FC—Darkness	48	52	34
Red—Darkness	32	41	63
Blue—Darkness	40	52	65
Green—Darkness	39	64	91

The reaction time of the three genera varied in the different gradients. However, *Eurycea b. bislineata* reacted fastest in all gradients shown in Table 5 except the 3 f.c.-darkness gradient, and green-darkness where *Pseudotriton montanus diastictus* was the fastest.

Desmognathus f. fuscus is intermediate to the other two genera in all of the gradients in Table 5 except 3 f.c.-darkness and green-darkness, where it was the slowest.

In response to a white light of 3 f.c., the reaction time of *Pseudotriton montanus diastictus* was about ten times as fast as it was in 25 f.c. *Eurycea b. bislineata* showed no difference to the two intensities and *Desmognathus f. fuscus* showed a slight variability.

When these animals were subjected to a gradient involving two types of light most of them stayed in white light more than in monochromatic light, the lone exception being *Eurycea b. bislineata* in 3 f.c.-blue gradient (See Table 6). This again indicates a tendency for

Table 5. Reactions to Various Light Gradients (Ten 15 Minute Tests Per Genus Per Gradient)

Gradient	Eurycea	Desmognathus	Pseudotriton
		Seconds	
25 FC–Darkness	19	29	38
3 FC–Darkness	17	21	3
Red–Darkness	21	30	42
Blue–Darkness	23	34	34
Green–Darkness	29	48	2

Table 6. Reactions to Various Light Gradients (Ten 15 Minute Tests Per Genus Per Gradient)

Gradient	Eurycea	Desmognathus	Pseudotriton
	Per Cent Time in Three Foot Candles		
3 FC–Red	64	64	53
3 FC–Blue	44	50	58
3 FC–Green	81	60	100

these three genera to be positively phototactic. The majority of workers have found salamanders to be negatively photo-tactic in this type of gradient. However, Vernberg (1955) did find *Plethodon cinereus* to be strongly positively photo-tactic in a 1 f.c.-green gradient.

It was noted that in five of the gradients *Eurycea b. bislineata* had the greatest number of crossovers (See Table 7). *Desmognathus f. fuscus* had the greatest number of crossovers in three of the gradients, the being the green-darkness, blue-darkness and the 3 f.c.-green gradients. *Pseudotriton montanus diastictus* was the least active genus in the study. It seems that *Eurycea b. bislineata* is more active than *Desmognathus f. fuscus* and *Pseudotriton montanus diastictsu* in most of the gradients studied.

A second type of light gradient was employed (See Materials and Methods for a description). Thirty-six tests were made with this gradient. Each test lasted for 30 minutes. A single salamander was tested each time, not several simultaneously (Hutchinson, 1958). The results of this second method of light response seemed to substantiate those results recived in the other gradients. Table 1 shows the results obtained with the light trough gradient. *Eurycea* has a tendency to be negatively photo-tactic, whereas, *Desmognathus f. fuscus* and *Pseudo-*

Table 7. Reactions to Various Light Gradients (Ten 15 Minute Tests Per Genus Per Gradient)

Gradient	Eurycea	Desmognathus	Pseudotriton
		Number of Crossovers	
25 FC—Darkness	47	43	20
3 FC—Darkness	44	34	16
Red—Darkness	36	26	10
Blue—Darkness	31	32	11
Green—Darkness	33	37	1
3 FC—Red	33	23	14
3 FC—Blue	29	22	4
3 FC—Green	25	38	0

triton montanus diastictus have a preference for the light end of the gradient. These results are analogous to those shown in Table 4.

Soil Moisture: Many workers have made observations on salamanders in relation to moisture. Both Bishop (1927) and Shelford (1913) have made field observations on the influence of moisture on various species of salamanders. Rosenthal (1935) has reported on the importance of soil moisture to *Aneides lugubris.* Vernberg (1953) has reported on the role of soil moisture in relation to *Plethodon cinereus.*

Table 2 gives the responses of the salamanders to a soil moisture gradient. All of the animals proved to indicate a greater preference for the moist end of the gradient.

Soil pH: The reactions of salamanders to soil pH has been scantily reported in the literature. When tested in the laboratory, *Eurycea b. bislineata* and *Desmognathus f. fuscus* showed a slight preference for an acid soil pH (6.3), spending 56% of the time there, while 44% of the time was spent in the soil of pH 7.1. *Pseudotriton montanus diastictus* showed a preference for the alkaline soil, spending 75% of the time there as opposed to 25% in an acid soil (See Table 3).

Of the thirty times animals were introduced into the more acid soil, only six failed to cross over to the alkaline side, but for the thirty times the animals were introduced into the alkaline side, sixteen animals did not cross over. *Eurycea b. bislineata* was more active than *Desmognathus f. fuscus* with 44 crossovers for *Eurycea b. bi-*

slineata and 36 for *Desmognathus f. fuscus. Pseudotriton montanus diastictus* was the least active of the three with only 10 crossovers.

Summary

A comparative behavior study of the genera *Eurycea, Desmognathus, and Pseudotriton* was made in regard to responses to gradients of light, pH, and soil moisture.

In general, *Desmognathus f. fuscus* and *Pseudotriton montanus diastictus* showed a preference for being positively photo-tactic; while *Eurycea b. bislineata* showed a tendency to be negatively photo-tactic for all light-darkness gradients except 25 f.c.-darkness and 3 f.c.-darkness gradients which were borderline cases. *Desmognathus f. fuscus* was negatively photo-tactic for red-darkness only; being positively photo-tactic for all other light-darkness gradients.

Eurycea b. bislineata showed a faster "reaction time" than did *Desmognathus f. fuscus* or *Pseudotriton montanus diastictus* in a majority of the light-darkness gradients.

Eurycea b. bislineata was considered to be more active based on the number of crossovers.

A light gradient trough was used for comparison purposes and the results were similar to those of the box gradient in that *Eurycea b. bislineata* was negatively photo-tactic and *Desmognathus f. fuscus* and *Pseudotriton montanus diastictus* were positively photo-tactic.

In the soil moisture experiments, all three genera had a preference for the moist end of the gradient (55 to 57.1% moisture) as opposed to the drier end of the gradient (20.9 to 33.9% moisture).

In reactions to soil pH, *Eurycea b. bislineata* and *Desmognathus f. fuscus* indicate a tendency to prefer the acid soil, whereas, *Pseudotriton montanus diastictus* showed a preference for the alkaline soil.

Acknowledgments

The author expresses his gratitude to Dr. Roger W. Barbour for the construction of a light gradient trough and for critically reading this manuscript; to Drs. John M. Carpenter and Thomas C. Barr, Jr. for reading the manuscript; to Dr. Robert Kuehne for the loan of two glass terraria and for assistance in the determination of soil pH; to Dr. R. F. Hanau and Mr. Tony Powell for help in calculating the wave length and foot candle power of light bulbs; to Dr. H. A. Romanowitz for the loan of a foot candle meter and to Mr. Melvin Denner for assistance in weighing and drying the soil samples. All of the above named personnel are associated with the University of Kentucky.

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STUDIES ON THE PRAIRIE VOLE, *MICROTUS OCHROGASTER*, IN CENTRAL KENTUCKY

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This research is a study of the ectoparasites, relative body proportions, pelage, hematology, food preferences, and speed trials of *Microtus ochrogaster* in central Kentucky.

The species *Microtus ochrogaster* ranges from West Virginia to Wyoming and from southern Oklahoma to Manitoba and Alberta, Canada (Hall and Kelson, 1959).

Several early naturalists in this country have commented on the fluctuations in numbers of individuals and on the breeding and feeding habits of voles, Kennicott (1857) reported on the breeding, food storing and behavior of some captive voles. Quick and Butler (1885) described the habits of two species of *Microtus*: *ochrogaster* and *pennsylvanicus* in Indiana. Criddle (1926) reported on the mating and feeding habits of *Microtus orchrogaster* in Manitoba. Fisher (1945) gave an account of food and reproduction of the prairie vole in Missouri. Jameson (1947) has contributed a very comprehensive study of the prairie vole in Douglas County, Kansas. He concluded that this species uses twenty-five kinds of plants as food. Stores of food are laid underground; a maximum quantity found in a single cache was two gallons. Several ectoparasites are common to the prairie vole: two fleas, *Ctenopthalmus pseudagyrtes Baker* and *Ochropaeus leucopus* (Baker); one species of louse, *Hoplopleura acanthopus* (Burmeister) and two species of mites, *Laelaps kochi* Oudemans and *Atricholaelaps glasgowi* (Ewing).

Fifty-eight gravid females, according to Jameson, had an average of 3.4 embryos. Litters at the height of the breeding season are larger than at the end of the breeding season.

Barbour and Barbour (1950) reported some measurements of *Microtus ochrogaster* from Hart County, Kentucky. They recognized three size groups based on twelve specimens. The largest specimens are grizzled in appearance and have the following measurements: total length, 145 (142-149); tail, 32 (28-35); hind foot, 19.7 (19-20). A smaller group, represented by seven specimens, averages: total length, 120.4 (112-126); tail, 24.8 (22-28); hind foot, 18.2 (18-19). Of this group, five are nearly uniform dorsally; the remaining two were beginning to exhibit the grizzled appearance of the adult. The third size group is represented by a single specimen and measures: total length, 98; tail, 17; hind foot, 15.

Materials and Methods

The information in this account was obtained by examining trapped animals and by observing live-trapped animals. Sixty-three prairie voles were snap-trapped during 370 trap nights. All specimens were collected on the University of Kentucky Experimental Farm except for three which were live-trapped in a rural area near Lexington, Kentucky. Twenty-five live traps were built from quart tin cans from which the ends had been removed. A piece of hardware cloth was attached over one end and a mouse trap was attached to the other end which had a piece of hardware cloth fastened to the guillotine to close the can when triggered. A piece of cotton was placed inside the can for the protection of the voles from low temperatures.

Two hundred and four slides were made of ectoparasites which were taken from the vole hosts. Each vole, when removed from a trap, was placed in a paper bag which was rolled up and a rubber band placed around it to prevent the escape of ectoparasites. When a vole was removed for ectoparasite examination, it was immediately placed on a large piece of paper and brushed in order to remove some of the ectoparasites. After this a careful examination of the pelage was made by observing the animal under a double ocular microscope. When a parasite was found, it was removed from the host and mounted on a microscope slide. For ectoparasite removal, an instrument was made by inserting a small insect pin into a wooden applicator stick. The ectoparasites were mounted in Hoyer's medium (See Strandtmann and Wharton, 1958, for ingredients).

Ectoparasites, which contained a lot of blood, were placed for about an hour in a 2-3 per cent potassium hydroxide solution. Next, they were carefully punctured with an insect pin to release the blood meal, then washed and mounted.

Standard measurements were made and recorded in millimeters. The weight was recorded in grams.

The pelage of the juveniles and adults was described. The names of the colors were taken from the Dictionary of Color by Maerz and Paul (1950).

Red blood cell counts were made with a hematocytometer; red blood cell diameters were measured using a micromter ocular and hemoglobin determinations were made using a Bausch and Lomb Spectrophotometer, Model 340.

In order to obtain blood for this work, the voles were given abdominal injections of nembutal and after the animal had succumbed, an incision was made in the thoracic region. The blood sample was removed from the heart with a small syringe.

One adult male and one adult female were placed together in a terrarium; glass petri dishes were filled with equal amounts of different grains. The grain dishes were checked at intervals of five days, the data recorded and the dishes refilled with other types of grain.

Time trials were conducted by measuring off an area 25 feet long on a tile covered floor. The width of the runway was six inches. A wall of the building served as one side of the runway and cardboard boxes were used for the other side. The specimens were timed by releasing them at the starting point and recording the time when they crossed the line. If the animal hesitated or did not immediately run to the end of the runway, the trial was discarded. Each vole was used only once during the trial runs. Shouting and clapping of the hands served as a stimulus for the start of each trial run. A Thalco 1/10 antimagnetic stopwatch was used for the timing of the speed trials.

Results

In the grassland habitat the pine mouse, *Pitymys pinetorum* and the large short-tailed shrew, *Blarina brevicauda,* were commonly found in the traps in the runways of the prairie vole. Less frequently trapped were the white-footed mouse, *Peromyscus leucopus* and the house mouse, *Mus musculus.*

Ectoparasites

The pelage of the prairie vole and other small mammals is a suitable habitat for many types of ectoparasites.

Fleas *(Siphonaptera)*

One species of flea was taken from the host.

Ctenopthalmus pseudagyrtes (Baker)

Typholpsylla assimilis Baker, 1895, Can. Ent., 27:190.
(not *T. assimilis* Taschenberg)

This genus is represented in the east by a single species which is exceedingly common on various small mammals. Fox (1944); Matheson (1950); Fritz and Pratt (1954).

This flea was recorded by Jameson (1947) from *Microtus ochrogaster* in Kansas and by Judd (1950) from a related species, *Microtus p. pennsylvanicus, in* Ontario.

Lice (Anoplura)

Hoplopleura acanthopus (Burmeister)

Pediculus acanthopus Burmeister 1839, Genera Insectorum, Rhynchota, Number 5; Plate 1, figure 2.

Lice collected from the prairie vole were all of one species, *Hoplopleura acanthopus* (Burmeister). This louse was found in abundance on the prairie vole by the writer.

The same species has been recorded from *Microtus orchrogaster* by Jameson (1947). This louse has been recorded from a total of seven species of *Microtus* in Europe and the United States (Fox, 1951).

Mites

Eulaelaps stabularis (Koch) (Strandtmann and Wharton, 1958)
Laelaps stabularis Koch 1839

This mite was found on the prairie vole by the writer but not in any abundance. This species was recorded from Kansas and it is listed as commonly occurring on *Microtus ochrogaster*. This mite has also been recorded on *Apodemus sylvaticus* and *Clethrionomys glareolus* in England. (Jameson, 1947)

Haemolaelaps glasgowi (Ewing)

Laelaps (*Haemolaelaps*) *marsupialis* Berlese 1910 (Strandtmann and Wharton, 1958)

This species of mite was found to be common on the prairie vole in this study.

Haemolaelaps glasgowie has also been recorded from *Microtus ochrogaster* in Kansas. It has been reported from several species: *Pitymys pinetorum* at Point Albino, Welland County, Ontario; on *Microtus pennsylvanicus* at Calaveras Dam, Almeda County, California. (Jameson, 1947)

Undetermined Mites

Representatives of three families of mites were collected in this study which could not be determined to species. They are as follows: Listrophoridae, two species; Laelaptidae, one or two specis and Trombiculidae, one species.

Family Listrophoridae Canestrini 1892

The family Listrophoridae belongs to the superfamily Sarcoptoidea which is parasitic on mammals mainly (Matheson, 1950).

Jameson (1947) recorded *Microtus ochrogaster* as being host to two genera of mites from the Family Listrophoridae: *Myocoptes* and *Listrophorus.*

Family Laelaptidae Berlese 1892

In addition to the two species of Laelaptid mites, *Eulaelaps stabularis* (Koch) and *Haemolaelaps glasgowi* (Ewing), one or possibly two other species of the Family Laelaptidae were collected.

Jameson (1947) recorded four species of the family from *Microtus ochrogaster* in Douglas County, Kansas.

Family Trombiculidae Ewing 1944

The trombiculid mites are commonly known by their larvae which are called chiggers or harvest mites. One unidentified species of chigger was taken in this study.

Jameson (1947) recorded one species, *Ascoschongastia brevipes* (Ewing) from *Microtus ochrogaster* and suggests that others may be involved.

Ticks

I recorded no ticks from the prairie vole in this study. Apparently, ticks are a rarity on this host as Jameson (1947) reported finding only two species of ticks: one adult, *Ixodes sculptes* and one nymph of *Dermacentor variabilis* (Say).

It is to be noted that of the ectoparasites I recorded in this study, none are new records for the species host, *Microtus ochrogaster.* However, it is to be noted that this work proves that several species of ectoparasites recorded by Jameson in the extreme western part of the range are to be found also in the eastern part of the range. This would serve as a basis for future investigators who might attempt a study of geographic variation of the ectoparasites found on *Microtus ochrogaster* throughout its range.

In recording the body measurements, the average is given first followed by the extremes in parentheses.

The variation in total length is extensive. The males had a measurement of 134.65 (113-153); and in the females 131.08 (110-160).

In the male series the tail length measurement proved to be 28.47 (15-40); and in the female series 26.88 (19-38). The tail length varied proportionately with the total length, the latter averaging 4.9 times the former.

The hind foot measurement of the males was 17.68 (15-20); and the females, 16.80 (13-19). The hind foot varied independently of the tail length and the total length.

The male series had the following ear measurements 12.02 (8-16); the females, 12.04 (10-14). The ear varied independently of the hind foot and the total length.

The body weight of males was 27.65 (17-38) grams; the females being, 27.56 (19-39) grams. These weights indicate that the two sexes are similar in body size.

The variation in these measurements between the sexes is so slight it can be considered insignificant. For the relative body proportions, all measurements were considered together without regard of the sex of the animals.

Pelage data is based on an examination of twenty adult (ten male and female) specimens and ten juveniles. All of the specimens were trapped during the autumn months. The capitalized terms are after Maerz and Paul's Dictionary of Color.

Juveniles: The dorsal surface is dark on the mid-dorsal surface and becomes lighter on the flanks. An examination of the individual hairs reveals that more gray hairs show through on the mid-dorsal surface than on the flanks which exhibit, in general, a tri-color pattern. The hairs on the flanks have a Dove Grey base, a light yellow, Golden Corn middle portion and a Chocolate colored tip.

The ventral surface is darker than in adults; smaller hairs have a white base and an Iron Grey terminal tip with randomly scattered dark hairs. These dark hairs are apparently absent from the ventral surface of the adult pelage.

The feet have naked soles and a grayish pelage dorsally. The hair on the dorsal surface of the feet is not as dense as that of the adult animal.

The tail is bicolored and closely resembles the coloration of the adult tail being dark Chocolate on the dorsal surface and Buff on the ventral surface.

Adults: The gross appeaarnce of the ventral surface is gray sprinkled with buff. Most of the hair on the ventral surface is of the bicolored nature, having an Iron Grey base and white terminal tips. The pelage is, in general, darker in the throat and axillary regions where the hairs have a monocoloration of Iron Gray. Some hairs in the throat region retain the tricolored condition as exhibited on the dorsal surface.

The dorsal surface consists of hairs which are mostly tricolored: Light Dove Grey base; a light color in the center, being either Cinnamon or Bran and a dark terminal tip which approaches a Chocolate color. Some of the hairs are bicolored with a dark gray base and a yellowish tip. Long guard hairs have a gray base and a Chocolate point on the end.

The tail is distinctly bicolored and, in general, resembles the same pattern as the dorasal and ventral surface being a dark Chocolate brown on the dorsal surafec and a Buff color on the ventral surface.

The feet have a dorasal pelage that is white with a sprinkling of dark hairs, particularly on the lateral surface.

The information derived from the blood of four voles is shown in Table 1. Standard blood laboratory procedures were followed in the hematology work.

Table 1. Hematology Data for *Microtus ochrogaster*

Animal Number	RBC Count	Hemoglobin Grams %	Average RBC Diameter (Microns)	Body Weight (Grams)
1	9,600,000	8.7	5.2	31
2	9,450,000	8.6	5.1	33
3	9,550,000	8.7	5.4	25
4	8,600,000	8.5	4.9	21

One adult male and one adult female vole were placed in the same terrarium; four glass petri dishes were filled with the following foods: sunflower seeds, barley, oats, and wheat. During the first week a decided preference was shown for the sunflower seeds and oats over barley and wheat. During the second week only oats and barley were eaten. Sunflower seeds and wheat were provided during the third week and a preference was shown for the sunflower seeds over the wheat. During the fourth week the sunflower seeds and pumpkin seeds were made available; the sunflower seeds being preferred to pumpkin seeds. During the fifth week the preference for the foods offered was sunflower, oats, wheat and pumpkin seeds.

The speed of a mammal is difficult to determine with any degree of accuracy. The speed trials were run using a different vole each time. Three of the trials were ruled invalid because the animal paused along the test route. Of the seven good trials, the data is presented in Table 2.

The average time of the seven trials was 5.4 feet/second with extremes of 4.6-11.6 feet/second. In a similar experiment, *Microtus p. pennsylvanicus* was recorded as having a mean of 8.0 feet/second with extremes of 7.2-9.6 feet/second for three trials (Layne and Benton, 1954).

Table 2. The Speed of *Microtus ochrogaster*

Animal Number	Speed in Feet/Second
1	8.0
2	11.4
3	7.4
4	11.5
5	11.4
6	11.6
7	4.6

Summary

During the autumn of 1963 in the vicinity of Lexington, Kentucky, 63 snap-trapped specimens of the prairie vole (*Microtus ochrogaster*) were collected; and 18 live-trapped specimens were utilized in an experimental manner. Four other species of small mammals occur in the same habitat with the prairie vole, and frequently use its runways. One species of flea, *Ctenopthalmus pseudagyrtes* (Baker); one louse, *Hoplopleura acanthopus* (Burmeister); five species of mites, *Eulaelaps stabularis* (Koch), *Atricholaelaps glasgowi* (Ewing) and three species which were identified to the families: Listrophoridae, Laelaptidae and Trombiculidae, respectively were recorded. Data on relative body proportions were recorded. A description of the pelage coloration is presented. Hematological studies derived some information on red blood cell counts, red blood cell diameters and hemoglobin counts. Several feeding experiments were tried and the voles showed a preference for sunflower seeds, oats, wheat, barley, and pumpkin seeds, in that order. Speed trials gave an average speed of 9.4 feet/second with extremes of 4.6 and 11.6 feet/second.

Acknowledgments

The author wishes to express his gratitude to Dr. Jesse S. White for the identification of the ectoparasites used in this study.

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ACADEMY AFFAIRS

Minutes of the Fall of 1964 Annual Business Meeting

The Annual business meeting of the Kentucky Academy of Science was called to order by Richard Chapman on Saturday morning, October 24, 1964 at 8:15 A.M. in room 101 Lappin Hall on the campus of Morehead State College.

The minutes of the 1963 meeting were read and approved.

The treasurer's report was given by J. H. B. Garner. It was moved that the report, previously audited by J. Carpenter, P. Sears, and R. Wiseman, be accepted. The motion carried.

Ray Jordan reported a membership of 1073 high school students in 37 Junior Academy clubs in the state. He pointed out that a report on the history of the Junior Academy has been published in Vol. 3-4 of the 1963 Transactions and also in the December, 1963 report of A.A.A.S. The 1963 fall meeting was held at Model High School on November 23 with a science fairs theme and with an attendance greater than 20. The science fair was held at the University of Kentucky on April 23-24 with an attendance greater than 300. Two students were sent to the National Science Fair in Baltimore in May. Mr. Jordan indicated that the Office of Education of the Health Education and Welfare Department is holding money for the promotion of science in Kentucky. The committee of Science Youth Activities originally set up by F. Dickey and the Junior Academy of Science are applying for this money through the state education department. Support is being requested for regional science fairs. The state fair is annually organized by the Junior Academy of Science. R. Jordan's report was approved.

R. Barbour reported on the status of the Transactions. One issue, the fiftieth anniversary issue, is to be published in 1964. He reported a general lack of response to his requests for special studies for the issue. The issue is to be made up of three parts: 1. The history of the Academy. 2. Early explorations and explorers in Kentucky up to 1914. 3. Explorations and explorers in Kentucky from 1914 to the present. R. Barbour's report was approved.

M. Wharton reported that she had been unable to attend the A.A.A.S. meeting last December but that she had received a detailed report from the previous year's meeting in which Natural Areas as Research Facilities was the major topic. She invited members of the Academy to borrow the report from her.

R. Jordan reported that he had attended the A.A.A.S. meeting and brought the following suggestions.

1. Annual report of Academy activities be submitted to A.A.A.S.
2. Announcements, financial reports etc. be sent to Dr. Clinton Baker at Memphis.
3. A history of the Academy be sent to A.A.A.S. for the Academy Archives.
4. A representative to A.A.A.S. be appointed for a three year term and that he be a member of the Academy executive committee.

The executive committee reported on its action on the matter of expenses for attendance at A.A.A.S. meetings which had been referred to it at the last annual meeting. The committee recommended that the Academy regularly contribute $50.0 toward the expenses of each of two representatives. C. Haman moved that this be made retroactive to include R. Jordan since the expenses matter had been referred to the executive committee prior to his attendance at the last A.A.A.S. meeting. R. Wiley moved that the motion be amended to include M. Wharton for the meeting the prior year. Both motions carried. A list of new members was read for approval by the Academy. The list included:

O. J. Abbott
Dr. Earl A. Alluisi
Raymond C. Bard
Edward A. Barnhardt
J. T. Bryan, Sr.
Edward E. Burkman
Edward K. Burton
Lois J. Campbell
John A. Cheek
Clarence Chesnutt
Howard R. Clark
Donald Allen Courtney
Sister Casimir Czurles
George O. Dawson
Robert E. Dawson
Thomas P. Field
Frank A. Gilbert
Arthur C. Glasser
Annette W. Gordon
Marshall Gordon
Eugene G. Haas
Lawrence C. Hartlage
Mrs. Carl M. Hill
Carl M. Hill
William R. Hourigan
John Randall Keith
William Edgar King
Victor G. Latrich
Curtis A. Logsdon
Mrs. Alvin McGlasson
Maurice K. Marshall
Dr. David L. Medley
Hubert C. Mohr
Dr. Charles W. Moore
George C. Moore
Margaret Morton
John W. Oswald
Willis Parkhurst
Charles A. Plank
Grace Quinto
David H. Rembert, Jr.
Marvin W. Russell
Darnell Salyer
Alice Van Krevelen
Harold D. Webster
John C. Williams
Joseph W. Wilson

The new members were approved.

R. Chapman reported for the Visiting Scientist committee (L. Alexander, J. Black, J. Conkin, E. Hammaker, L. Lancaster, D. Lindsay, H. Nollau, W. Read, C. Whittle, and R. Chapman). He indicated that 462 high schools had been sent the visitor roster list of 105 scientists. Twenty-one requests have been received to date and a total of about 75 are anticipated to be possible with the $8005.00 grant. Dr. E. Fergus is acting as director of the program. Another proposal will be sent to the N.S.F. before January 1.

Prior to the business meeting the executive committee met with the Visiting Scientists Advisory committee to consider two requests that do not fall in line with the proposed activities for the N.S.F. program. The committee recommended that the Academy send three representatives, as has been requested, to the Elementary Science Teacher's Congress to be held in Campbellsville in November and that the Academy send five representatives to the Junior Academy fall meeting to be held at Central City. It was suggested that funds be used from that portion of the N.S.F. grant designated as overhead and which the executive committee feels should be used for purposes such as these. It was moved and seconded that the above procedure be followed. The motion carried.

The research committee, C. B. Hamann, M. Wharton, and H. Nollau, reported that no research proposals had been submitted. C. Hamann suggested that the funds be held over if necessary until next year and that in the meantime high school teachers be advised of the possibility of applying for these funds.

E. Browne reported on the status of the Kentucky Flora project initiated four years ago as suggested at the K.A.S. meeting in Louisville. The study had been sanctioned by the Academy so that in the event the N.S.F. supported such projects money might have become available more readily for the study. The N.S.F. indicated that they did not support such projects but E. Browne indicated the study had gone ahead without such support.

It was moved and seconded that the constitutional amendment regarding meeting time of the Academy be accepted. The amendment to Article IX Section

I reads "The regular meeting time of the Kentucky Academy of Science shall be held in the spring at such time and place as executive committee shall select". R. Chapman pointed out that several other constitutional amendments would become necessary as a result of the above. It was moved and seconded that the preceding motion be tabled. The motion carried.

J. Chaplin, chairman of the geology section, moved that the name of that section be changed to Geology and Geography and that emphasis should be placed on physical geography. The motion was seconded and carried.

R. Chapman read a letter from President John Oswald inviting the Academy to meet at the University of Kentucky for the 1965 fall meeting. He suggested the possibility of meeting concurrently with the Biological Adaptation Conference on November 11 and 12 which will be held at the University as one of the centennial events. W. Owsley mentioned that he had come prepared to invite the Academy to meet at Kentucky Wesleyan but in view of the circumstances he would postpone his invitation to a later date. It was moved and seconded that the executive Committee accept the invitation from the University of Kentucky. The motion carried.

The nominating committee, R. Barbour, L. Lancaster, and G. Wilson, presented the following slate of nominees:

President elect:	J. Carpenter
Vice President:	R. Boyer
Secretary:	D. Lindsay
Treasurer:	J. H. B. Garner
Representative to A.A.A.S. Council:	M. Wharton
Representative to Academy Conference:	R. Jordan
Board of Directors:	W. Owsley A. M. Wolfson

It was moved that the slate be elected unanimously. The motion was seconded and carried.

The meeting adjourned at 10:00 A.M.

Gerrit Levy, Secretary

The officers who were elected at the sectional meetings are as follows:

Microbiology
Lucia Anderson, Chairman
J. N. Baldwin, Secretary

Botany
J. H. B. Garner, Chairman
Gordon E. Hunter, Secretary

Geology & Geography
Zelek L. Lipchinsky
David K. Hylbert, Secretary

Chemistry
Darnell Salyer, Chairman
N. Thornton Lipscomb, Secretary

Psychology
Earl Alluisi, Chairman
Mary Ellen Curtin, Secretary

Physics
Julian Pike, Chairman
Fletcher Gabbard, Secretary

Zoology
Herbert E. Shadowen, Chairman
William W. Norris, Jr., Secretary

Sectional Meetings

MICROBIOLOGY SECTION

Lappin Hall, Room 312
Emil Kotcher, Chairman
Lucia Anderson, Secretary

1. Vaccination against Western equine encephalitis virus. L. N. Bare and I. Ruchman, Department of Microbiology, University of Kentucky.
2. Control of penicillinase production in *Staphylococcus aureus*. S. Hastowo and J. N. Baldwin, Department of Microbiology, University of Kentucky.
3. Possible genetic relationship between penicillinase and methionine markers. W. Tien and J. N. Baldwin, Department of Microbiology, University of Kentucky.
4. A bioactive substance in the cecal content of germfree animals. R. F. Wiseman and H. A. Gordon, Departments of Microbiology and Pharmacology, University of Kentucky.

BOTANY SECTION

Lappin Hall, Room 210
Edward T. Browne, Jr., Chairman
Robert Larance, Secretary

1. Edward T. Browne. Floristic studies in Pike County, Kentucky. Botany Department, University of Kentucky.
2. Hari Suseno and R. E. Hampton. The Effect of Three Strains of Tobacco Mosaic Virus on Phenoloxidase and Perodxidase in Tobacco. Plant Pathology Department, University of Kentucky.
3. H. P. Riley. The Golden Jubilee of the National Botanical Gardens of South Africa. Botany Department, University of Kentucky.
4. S. K. Majumdar. Male sterility in *Hevea brasiliensis*. (Gradute student) Botany Department University of Kentucky.
5. T. G. Nye, H. P. Riley, and J. C. Warden. An Ecological Study of *Draba ramosissima* Desv. with notes on the Intraspecific Taxonomy and Leaf Morphology of this Species. Botany Department, University of Kentucky.
6. David H. Rembert, Jr., and J. M. Herr, Jr. The Taxonomic Significance of Megasporogenesis in *Wisteria sinensis* Sweet. (Dr. Herr is associate professor at the University of South Carolina) Rembert is a graduate student, Botany Department, University of Kentucky.

7. James A. Salyer, Jr. Plant Communities at White Oak Creek. (Graduate Student) Botany Department, University of Kentucky.
8. A Preliminary Survey of the Fungi Found on the Healthy Bark of the Trembling Aspen (populus tremuloides Michx) by J. H. B. Garner, Botany Dept., Univ. of Kentucky.

GEOLOGY SECTION

Lappin Hall, Room 409
Ellis Brown, Chairman
Darnell Salyer, Secretary

1. "Design Calculations for a Small Peltier Refrigerator," E. B. Penrod, University of Kentucky.
2. "Binding of Azo Compounds to Liver Proteins," Joseph Hendon and Ellis V. Brown, University of Kentucky.
3. "Derivatives of 2- and 4- methyl- 1,8-naphthyridines," Ellis V. Brown, University of Kentucky.
4. "The Structure of Cyclooctane," Donald Sands and Victor W. Day, University of Kentucky.
5. "The Application of Simple Huckel M. O. Calculations to Substituted Benzenediaonium Compounds," Charles Girard, Office Products Division, I.B.M., Lexington.
6. "Quantum Yield Determinations of Substituted Benzenediazonium Compounds," Francis Clarke, Office Products Division, I.B.M., Lexington.
7. "Kinetics of the Polymerization and Styrene Copolymerization of Meta and Para Divinylbenzene," Richard H. Wiley and Giovanni DeVenuto, University of Louisville.
8. "The N.M.R. Characteristics of some Substituted Styrenes," Thomas H. Crawford, University of Louisville.
9. "The Question of Bonding in Metallic Hydrides," William B. Bos, University of Louisville.

7. "Kinetics of the Polymerization and Styrene Copolymerization of Meta and Para Divinylbenzene," Richard H. Wiley and Giovanni DeVenuto, University of Louisville.
8. "The N. M. R. Characteristics of some Substituted Styrenes," Thomas H. Crawford, University of Louisville.

PSYCHOLOGY SECTION

Lappin Hall, Room 206
Alice Van Krevelen, Chairman
Mary Ellen Curtin, Secretary

INTERDISCIPLINARY CONTRIBUTIONS TO THE PSYCHOLOGICAL STUDY OF HUMAN BEHAVIOR

Dr. James Gregor, Philosophy Department, University of Kentucky. Representing Social Philosophy.

Dr. Shepharo Walker, University of Louisville Medical School. Representing Neuro-physiology.

Dr. John Donahoe, Psychology Department, University of Kentucky. Representing Psychology.

Dr. Lewis Cochran, Psychology Department, University of Kentucky. Representing Physics.

Dr. Earl A. Alluisi, Psychology Department, University of Louisville, Moderator.

You are urged to be present and to bring with you as guests any students you feel might profit from the program.

Other interested individuals are also welcome.

Open discussion will follow the papers.

ZOOLOGY SECTION

Lappin Hall, Room 113
John C. Williams, Chairman

1. A Study of a Clifty Creek Rock Shelter 10 min. Dr. L. Y. Lancaster, Biology Department, Western Kentucky State College.
2. *Specificity of Action of some Enzymes in Meat Tenderizers (Histological Evaluation).*
   Dr. William W. Norris, Jr., Biology Department, Western Kentucky State College.
3. Use of the Predatory Mite, *Macrocheles muscaedomesticae* for the Control of *Fannia canicularis* in Poultry Houses.
   Pritam Singh and J. G. Rodriguez, Department of Entomology and Botany, University of Kentucky.
4. A Comparative Study of the Weberian Apparatus of Nine Species in the Genera *Dionda* and *Notropis* (Pisces: Cyprinidae).
   Dr. Morgan E. Sisk, Biology Department, Murray State College.
5. A Severe Case of Trichimoniasis in a Pigeon. J. M. Edney, Zoology Department, University of Kentucky.
6. Physico-Chemical Variability on Headwater Streams near Lexington, Kentucky.
   Robert Kuehne, Zoology Department, University of Kentucky.

PHYSICS SECTION

Lappin Hall, Room 105
Bernard D. Kern, Chairman
Otis K. Wolfe, Secretary

10:00 A.M.

(Program being organized at time of this printing)

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Volume 26 — 1965

Editorial Office

Department of Plant Pathology
University of Kentucky
Lexington, Kentucky

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THE KENTUCKY ACADEMY OF SCIENCE

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TRANSACTIONS of the KENTUCKY ACADEMY of SCIENCE

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KENTUCKY ACADEMY OF SCIENCE

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The Kentucky Academy of Science

Founded May 8, 1914

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A REVISED CHECKLIST OF KENTUCKY MOSSES

DAVID BICKEL[1]
Department of Biology, University of Louisville, Louisville, Kentucky

The mosses of Kentucky have received little attention and published records show that many areas of the state have been completely neglected. This paucity of information tends to complicate bryogeographic studies in that it is often difficult to determine if irregularities in distribution result from insufficient collecting or represent actual ranges of mosses (Anderson, 1943).

It is worth noting that only 57 of Kentucky's 120 counties (Figure 1) are mentioned in published lists, and in most cases these records are from one or a few collections. Large areas in central and western Kentucky remain unexplored. The few detailed studies include the work of H. T. Shacklette in some western areas, the collections of E. Lucy Braun, and floral studies in Kenton, Whitley, and McCreary counties. Findings from these were published by Fulford and Shacklette (1942). Felix (1958) compiled a moss flora for Harlan County. Reports from similar concentrated efforts or from casual collecting in other parts of the state would be worthy contributions to bryology.

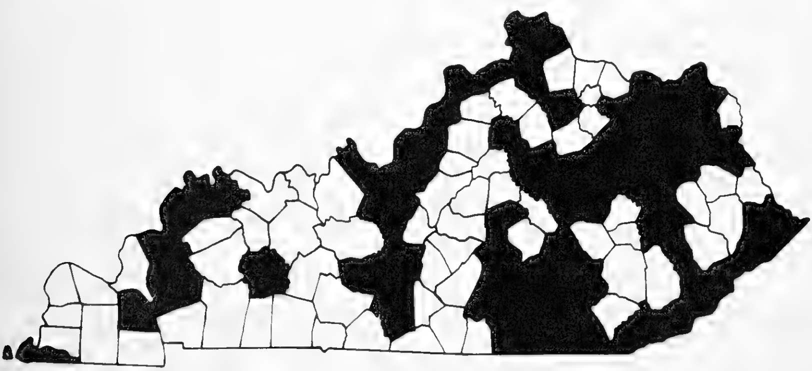

Fig. 1.—Outline map of Kentucky. Darkened areas are counties that have some published moss records.

Previous lists of the state flora were composed by Short (1837), Smith (1927), and Fulford and Shacklette (1942). Smith (1927) reported 25 moss species but unfortunately the locality for the entire collection was given as "Natural Bridge, Kentucky River region, Berea,

[1] Present address: Ohio State Museum, Columbus, Ohio.

Rockcastle County, and other mountain districts". Fulford and Shacklette recorded 167 species and 14 varieties based on 800 collections from 47 counties, and this catalog remains the most extensive study carried out in Kentucky. Species were added by Crum (1954 and 1956) and Felix (1958), and single additions were disclosed by Anderson (1943) and Welch (1960). Crum (1956), after examining material originally reported by Fulford and Shacklette, deleted two species, *Thuidium scitum* and *Funaria americana*, from the 1942 list.

Included in the following revision are five additions to the flora (indicated by asterisk) and various county records that were collected by the author from spring, 1963 through spring, 1965. The list contains 209 species and varieties. Specimens of the new additions are deposited in the Herbarium of the University of Louisville.

Sphagnaceae

Sphagnum compactum DC. McCreary and Powell counties.
Sphagnum fuscum (Schimp.) Klinggr. Powell County.
Sphagnum magellanicum Brid. Powell and Whitley counties.
Sphagnum palustre L. McCreary County.
Sphagnum robustum (Russow) Roll. Powell County.
Sphagnum strictum Sull. Fleming County.
Sphagnum subsecundum Nees. Harlan and Wolfe counties.
Sphagnum tenerum Sull. & Lesq. Powell County.

Andreaeaceae

Andreaea rothii W. & M. Harlan County.

Tetraphidaceae

Tetraphis pellucida Hedw. Caldwell, Carter, Elliott, Lewis, Powell, Whitley, and Wolfe counties.

Polytrichaceae

Atrichum angustatum (Brid.) Bry. Eur. Harlan County.

Atrichum crispum (James) Sull. Montogomery County, also reported by Smith (1927).

Atrichum macmillani (Holz.) Frye. Bath, Henderson, Letcher, McCreary, Marshall, Meade, Muhlenberg, Perry, Pike, and Union counties.

Atrichum undulatum (Hedw.) Beauv. Boone, Edmonson, Elliott, McCreary, Marshall, Meade, Perry, Pike, Powell, Roman, Whitley, and Wolfe counties.

Pogonatum brachyphyllum (Rich.) Beauv. Harlan County.

Pogonatum pensilvanicum (Hedw.) Paris. Bath, Harlan, Lewis, McCreary, Marshall, Pike, Powell, and Wolfe counties.

Polytrichum commune Hedw. Harlan, Laurel, Letcher, Pike, and Powell counties.

Polytrichum juniperinum Hedw. Carter, Letcher, Pike, Powell, Union, and Wolfe counties.

Polytrichum ohioense R. & C. Bath, Boone, Carter, Elliott, Fleming, Harlan, Lewis, McCreary, Muhlenberg, Perry, Pike, Powell, Rowan, Russell, Whitley, and Wolfe counties.

Polytrichum piliferum Hedw. Powell County.

Fissidentaceae

Bryoxiphium norvegicum (Brid.) Mitt. Caldwell, Carter, Elliott, Menifee, Powell, and Wolfe counties.

Fissidens adiantoides Hedw. Carter County.

Fissidens bryoides Hedw. Elliott County.

Fissidens bushii Card. & Ther. Bullitt, Jefferson, and Oldham counties.

Fissidens cristatus Wils. Jessamine, Letcher, Powell, Union, and Whitley counties.

Fissidens debilis Schw. Bullitt, Jefferson, Meade, Oldham, and Union counties.

**Fissidens grandifrons* Brid. Hart County.

Fissidens hyalinus Hook. and Wils. Kenton County.

Fissidens obtusifolius Wils. Jefferson and Whitley counties.

Fissidens osmundioides Hedw. Boone, Carter, McCreary, Powell, and Whitley counties.

Fissidens subbasilaris Hedw. Pike County.

Fissidens taxifolius Hedw. Boone, Carter, Henderson, Meade, and Powell counties.

Fissidens viridulus var. *incurvus* (Starke) Monkem. Carter, McCreary, and Whitley counties.

Ditrichaceae

Ceratodon purpureus (Hedw.) Brid. Carter, Fleming, Letcher, Menifee, Pike, and Union counties.

Ditrichum pallidum (Hedw.) Hampe. Bath, Boone, Caldwell, Carter, Henderson, Kenton, Letcher, Lyon, McCreary, Marshall, Perry, Pike, Powell, Whitley, and Wolfe counties.

Ditrichum pusillum (Hedw.) E. G. B. Carter and Wolfe counties.

Pleuridium acuminatum Lindb. Jefferson County.

Dicranaceae

Dicranella heteromalla (Hedw.) Schimp. Harlan, McCreary, Powell, Union, and Wolfe counties.

Dicranella heteromalla var. *orthocarpa* (Hedw.) Paris. Carter and Rowan counties.

Dicranella refescens (Smith) Schimp. Carter and Wolfe counties.

Dicranella varia (Hedw.) Schimp. Boone County.

Dicranodontium denudatum (Brid.) E.G.B. Harlan County.

Dicranum condensatum Hedw. Perry, Powell, and Whitley counties.

Dicranum flagellare Hedw. Elliott, Lewis, Powell, Pulaski, Whitley, and Wolfe counties.

Dicranum fulvum Hook. Harlan, Powell, and Whitley counties.

Dicranum fuscescens Turn. Letcher County.

Dicranum rugosum (Hoffm.) Brid. Bath, Estill, and Rockcastle counties.

Dicranum scoparium Hedw. Bath, Boone, Carter, Estill, Fleming, Lewis, Lyon, McCreary, Perry, Pike, Powell, Rowan, Union, Whitley, and Wolfe counties.

Dicranum spurium Hedw. Powell and Wolfe counties.

Dicranum viride (S. & L.) Lindb. Elliott County.

Leucobryaceae

Leucobryum albidum (Brid.) Lindb. Harlan, Perry, and Wolfe counties.

Leucobryum glaucum (Hedw.) Schimp. Bath, Boone, Carter, Clark, Elliott, Fleming, Laurel, Letcher, Lewis, Lyon, McCreary, Perry, Pike, Powell, Rowan, Russell, Whitley, and Wolfe counties.

Pottiaceae

Barbula convoluta Hedw. Powell County.

Barbula unguiculata Hedw. Kenton County.

Didymodon recurvirostris (Hedw.) Jenn. Powell County.

Eucladium verticillatum (Brid.) Bry. Eur. Crittenden County.

Gymnostomum calcareum N. & H. Elliott, Menifee, Powell, and Whitley counties.

Tortella humilis (Hedw.) Jenn. Harlan County.

Tortella caespitosa (Schw.) Limpr. Boone, Carter, McCreary, Meade, Powell, Whitley, and Wolfe counties.

Trichostomum tenuirostre (Hook. & Tayl.) Lindb. Powell County.

Weisia controversa Hedw. Harlan, Union, and Whitley counties.

Pottia truncata (Hedw.) Fuern. Henderson County.

Tortula pagorum (Milde) DeNot. Barren, Boyle, Fayette, and Pulaski counties.

Calymperaceae

Syrrhopodon texanus Sull. McCreary, Powell, and Whitley counties.

Grimmiaceae

Grimmia alpicola var. *rivularis* (Brid.) Broth. Pike County.

Grimmia apocarpa Hedw. Boone, Carter, Fleming, Franklin, Rowan, and Woodford counties.

Grimmia apocarpa var. *gracilis* (Schleich.) W. & M. Harlan County.

Grimmia apocarpa var. *nigrescens* Mol. Bullitt County.

Grimmia laevigata (Brid.) Brid. Letcher County.

Grimmia olneyi Sull. Powell and Wolfe counties.

Grimmia pilifera Beauv. Harlan and Whitley counties.

Hedwigia ciliata Hedw. Boone, Breathitt, Carter, Fleming, Harlan, Laurel, Lawrence, Letcher, Lewis, McCreary, Perry, Pike, Powell, Rowan, Union, Whitley, and Wolfe counties.

Ptychomitrium incurvum (Muhl.) Sull. Laurel, McCreary, Union, and Whitley counties.

Rhacomitrium heterostichum var. *ramulosum* (Lindb.) Jones. McCreary County.

Ephemeraceae

Nanomitrium synoicum (James) Lindb. Jefferson County.

Buxbaumiaceae

Diphyscium foliosum (Hedw.) Mohr. Harlan, Letcher, Lewis, Perry, Powell, and Whitley counties.

Funariaceae

Aphanorhegma serratum (H. & W.) Sull. Kenton and Union counties.

Funaria flavicans Mx. Fleming, Powell, and Union counties.

Funaria hygrometrica Hedw. Boone, Grant, Pike, Powell, Whitley, and Wolfe counties.

Funaria hygrometrica var. *calvescens* (Schw.) Bry. Eur. Menifee County.

Physcomitrium turbinatum (Mx.) Brid. Boone, Campbell, Carter, Fleming, Fulton, Henderson, Perry, and Whitley counties.

Orthotrichaceae

Drummondia prorepens (Hedw.) Jenn. Boone, Caldwell, Fleming, Harlan, Harrison, Meade, Powell, Union, Whitley, and Wolfe counties.

Orthotrichum anomalum Hedw. McCreary and Whitley counties.

Orthotrichum ohioense S. & L. Boone, Harlan, Henderson, McCreary, and Menifee counties.

Orthotrichum pusillum Mitt. Bullitt, Carroll, and Hardin counties.

Orthotrichum sordidum Sull. Fleming County.

Orthotrichum stellatum Brid. Boone County.

Orthotrichum strangulatum Schw. Clark County.

Ulota americana (Beauv.) Limpr. Harlan and Whitley counties.

Ulota crispa (Hedw.) Brid. Pike, Whitley, and Wolfe counties.

Timmiaceae

Timmia megapolitana Hedw. Boone County.

Aulacomniaceae

Aulacomnium heterostichum (Hedw.) Bry. Eur. Caldwell, Carter, Clark, Elliott, Harlan, Letcher, Lewis, McCreary, Marshall, Meade, Perry, Powell, Pulaski, Russell, and Whitley counties.

Aulacomnium palustre (W. & M.) Schw. Clark, Fleming, Harlan, Letcher, Pike, and Whitley counties.

Bartramiaceae

Bartramia pomiformis Hedw. Carter, Elliott, Harlan, McCreary, Marshall, Meade, Menifee, Pike, Powell, Pulaski, Rowan, Russell, Union, Whitley, and Wolfe counties.

Philonotis capillaris Lindb. Powell County.

Philonotis fontana (Hedw.) Brid. Lewis and Whitley counties.

Bryaceae

Bryum argenteum Hedw. Campbell, Madison, and Wolfe counties.

Byrum argenteum var. *lanatum* (Beauv.) Bry. Eur. Letcher County.

Bryum caespiticium Hedw. Elliott and Union counties.

Bryum pseudotriquetrum (Hedw.) Schw. Harlan, Powell, and Russell counties.

Pohlia nutans (Hedw.) Lindb. Lyon, Powell, Union, and Whitley counties.

Pohlia wahlenbergii (W. & M.) Andr. Boone, Perry, Powell, and Union counties.

Rhodobryum roseum (Hedw.) Limpr. Carter, Fayette, Franklin, Jessamine, Letcher, Lewis, McCreary, Menifee, Pike, Powell, and Wolfe counties.

Mniaceae

Mnium affine Bland. Harlan, Jessamine, Letcher, McCreary, Marshall, Powell, Union, Whitley, and Woodford counties.

Mnium affine var. *ciliare* (Grev.) C. M. Elliot, Kenton, McCreary, Pike, and Powell counties.

Mnium cuspidatum Hedw. Boone, Carter, Clark, Elliott, Fleming, Franklin, Harlan, Henderson, Letcher, Lyon, Powell, and Union counties.

Mnium hornum Hedw. Elliott, Morgan, Pike, Powell, Whitley, and Wolfe counties.

Mnium medium Bry. Eur. McCreary County.

Mnium orthorhynchum Brid. Elliott, Letcher, and Menifee counties.

Mnium punctatum Hedw. Elliott, Letcher, Lewis, McCreary, Powell, Union, Whitley, and Wolfe counties.

Mnium punctatum var. *elatum* Schimp. Letcher and Pike counties.

Mnium spinulosum Bry. Eur. Carter and Whitley counties.

Mnium stellare Hedw. Carter and Powell counties.

Hypnaceae

Amblystegiella confervoides (Brid.) Loeske. Bullitt and Oldham counties.

Amblystegium compactum (C.M.) Aust. Boone County.

Amblystegium juratzkanum Schimp. Fulton County.

Amblystegium serpens (Hedw.) Bry. Eur. Boone, Franklin, Greenup, Powell, and Whitley counties.

Amblystegium varium (Hedw.) Lindb. Boone, Meade, Powell, Union, Whitley, and Woodford counties.

Brachythecium oxycladon (Brid.) J. & S. Boone, Franklin, and Jessamine counties.

Brachythecium rivulare Bry. Eur. Meade County.

Brachythecium rutabulum (Hedw.) Bry. Eur. Boone County.

Brachythecium rutabulum var. *flavescens* (Brid.) Bry. Eur. Boone, Carter, Jessamine, and Lewis counties.

Brachythecium salebrosum (W. & M.) Bry. Eur. Boone, Harlan, McCreary, and Whitley counties.

Brachythecium velutinum (Hedw.) Bry. Eur. Boone County.

Brotherella recurvans (Mx.) Fleisch. Carter, Clark, Elliott, Harlan, Pike, and Powell counties.

Brotherella tenuirostris (Schimp.) Broth. Whitley County.

Bryhnia graminicolor (Brid.) Grout. Boone and Carter counties.

Bryhnia novae-angliae (S. & L.) Grout. Powell County.

**Calliergonella cuspidata* (Brid.) Loeske. Hart County.

Calliergonella schreberi (Brid.) Grout. Montgomery County.

Campylium chrysophyllum (Brid.) Bryhn. Boone, Carter, Edmonson, McCreary, Rowan, Whitley, and Woodford counties.

Campylium hispidulum (Brid.) Mitt. Boone, Powell, Rowan, and Whitley counties.

Climacium americanum Brid. Bath, Caldwell, Carter, Edmonson, Franklin, Harlan, Letcher, Lewis, McCreary, Meade, Pike, Union, Wayne, Whitley, and Woodford counties.

Climacium kindbergii (R. & C.) Grout. Lewis County.

Entodon cladorrhizans (Hedw.) C. M. Boone, Franklin, and Wolfe counties.

Entodon seductrix (Hedw.) C.M. Bath, Boone, Caldwell, Carter, Franklin, Fulton, Harlan, Henderson, Meade, Powell, and Union counties.

Eurhynchium hians (Hedw.) J. & S. Boone, Fleming, and Perry counties.

Eurhynchium pulchellum (Hedw.) Jenn. Boone and Letcher counties.

Eurhynchium pulchellum var. *robustum* Roell. Bullitt and Estill counties.

Eurhynchium riparioides (Hedw.) Jenn. Jessamine, Letcher, Powell, and Wolfe counties.

Eurhynchium serrulatum (Hedw.) Kindb. Boone, Campbell, Elliott, Fleming, Harlan, Henderson, McCreary, Powell, Whitley, and Wolfe counties.

Homalotheciella subcapillata (Hedw.) Card. Carter, Elliott, Fleming, and Lewis counties.

Homomallium adnatum (Hedw.) Broth. Bath, Boone, and Harlan counties.

Hygroamblystegium fluviatile (Sw.) Loeske. Boone, Franklin, McCreary, and Whitley counties.

Hygroamblystegium irriguum (Wils.) Loeske. Boone, Bullitt, Carter, Jefferson, Letcher, Meade, and Powell counties.

**Hygroamblystegium irriguum* var. *spinifolium* (Schimp.) Grout. Hart County.

Hygroamblystegium orthocladon (Beauv.) Grout. Harlan County.

**Hygrohypnum ochraceum* (Turn.) Loeske. Jefferson County.

Hylocomium brevirostre (Beauv.) Bry. Eur. Elliott and Wolfe counties.

Hypnum crista-castrensis Hedw. Wolfe County.

Hypnum curvifolium Hedw. Bath, Boone, Caldwell, Carter, Casey, Edmonson, Elliott, Fleming, Franklin, Harlan, Jessamine, Laurel, Letcher, Lewis, McCreary, Marshall, Meade, Perry, Powell, Rowan, Russell, Union, Whitley, and Wolfe counties.

Hypnum fertile Sendt. McCreary County.

Hypnum imponens Hedw. Bell, Carter, Clark, Elliott, Fleming, Harlan, Lewis, Perry, Pike, Powell, and Wolfe counties.

Hypnum molluscum Hedw. Elliott, Fleming, McCreary, Rowan, and Wolfe counties.

Hypnum patientiae Lindb. Boone, Powell, and Union counties.

Leptodictyum riparium (Hedw.) Warnst. Boone, Edmonson, Elliott, Hart, Jefferson, Union, Whitley, and Woodford counties.

Plagiothecium denticulatum var. *propagulifera* Ruthe. Boone County.

Plagiothecium deplanatum (Sull.) Grout. Boone, Elliott, Jessamine, Menifee, Whitley, and Woodford counties.

Plagiothecium elegans (Hook.) Sull. Fleming and Powell counties.

Plagiothecium geophilum (Aust.) Grout. Boone and Meade counties.

Plagiothecium micans var. *fulvum* (Hook. & Wils.) Paris. McCreary County.

Plagiothecium sylvaticum (Brid.) Bry. Eur. Powell County.

Platygyrium repens (Brid.) Bry. Eur. Bath, Boone, Elliott, Lewis, McCreary, and Whitley counties.

Porotrichum alleghaniense (C.M.) Grout. Carter, Jessamine, McCreary, Powell, Trimble, and Wolfe counties.

Pylaisia intricata (Hedw.) Bry. Eur. Bath County.

Pylaisia selwynii Kindb. Clark County.

Rhytidium rugosum (Hedw.) Kindb. Carter County.

Sciaromium lescurii (Sull.) Broth. Bullitt, Jefferson, McCreary, Powell, and Whitley counties.

**Scorpidium scorpioides* (Hedw.) Limpr. Jefferson County.

Sematophyllum adnatum (Mx.) E.G.B. McCreary County.

Sematophyllum carolinianum (C.M) E.G.B. Elliott, McCreary, Perry, and Whitley counties.

Sematophyllum marylandicum (C. M.) E.G.B. Whitley County.

Leskeaceae

Anomodon attenuatus (Hedw.) Hueben. Boone, Carter, Elliott, Fleming, Franklin, Greenup, Jessamine, Letcher, Lewis, McCreary, Marshall, Meade, Rowan, Union, Whitley, and Wolfe counties.

Anomodon minor (Beauv.) Lindb. Boone, Carter, Franklin, and Letcher counties.

Anomodon rostratus (Hedw.) Schimp. Boone, Carter, Elliott, Fleming, Franklin, Greenup, Laurel, Letcher, Lewis, McCreary, Meade, Powell, Rowan, Union, Whitley, and Wolfe counties.

Haplohymenium triste (Cesati) Kindb. Boone, Carter, Elliott, Franklin, McCreary, and Whitley counties.

Helodium paludosum (Sull.) Aust. Edmonson and Whitley counties.

Leskea gracilescens Hedw. Boone County.

Leskea obscura Hedw. Boone, Fulton, Gallatin, Henderson, Marshall, Union, and Whitley counties.

Leskea polycarpa Hedw. Boone County.

Myurella careyana Sull. Carter and Powell counties.

Thelia asprella Sull. Boone, Lewis, and Whitley counties.

Thelia hirtella (Hedw.) Sull. Bath, Boone, Carter, Elliott, Fleming, Jessamine, Lewis, McCreary, Powell, Rowan, and Whitley counties.

Thelia lescurii Sull. Jefferson County.

Thuidium abietinum (Brid.) Bry. Eur. Collected by Smith (1927).

Thuidium delicatulum (Hedw.) Mitt. Bath, Boone, Carter, Clark, Elliott, Fleming, Franklin, Harlan, Letcher, Lewis, McCreary, Pike, Powell, Rowan, Union, Whitley, and Woodford counties.

Thuidium pygmaeum Bry. Eur. Woodford County.

Thuidium recognitum (Hedw.) Lindb. Jessamine and Union counties.

Thuidium virginianum (Brid.) Lindb. Fleming, Fulton, and Marshall counties.

Hookeriaceae

Hookeria acutifolia Hook. Caldwell, Laurel, Powell, and Wolfe counties.

Neckeraceae

Neckera pennata Hedw. Harlan County.

Leucodontaceae

Leptodon ohioensis Sull. Boone, Elliott, Laurel, Whitley, and Wolfe counties.

Leptodon trichomitrion (Hedw.) Mohr. Carter, Franklin, McCreary, Rowan, and Wolfe counties.

Leptodon trichomitrion var. *immersus* (Sull. & Lesq.) Lesq. & James. Whitley County.

Leucodon brachypus Brid. Boone, Fayette, Pike, and Whitley counties.

Leucodon julaceus (Hedw.) Sull. Boone, Edmonson, Franklin, Harlan, Harrison, Lewis, Marshall, Powell, Rowan, and Whitley counties.

Leucodon sciuroides (Hedw.) Schw. Fleming County.

Fabroniaceae

Clasmatodon parvulus (Hampe) Sull. Fulton and Whitley counties.

Fabronia ravenelii Sull. Bath County.

Schwetschkeopsis denticulata (Sull.) Broth. Boone and Whitley counties.

Fontinalaceae

Fontinalis biformis Sull. Bullitt County.

Fontinalis disticha Hook. & Wils. Union County.

Fontinalis filiformis Sull. & Lesq. Union County.

Fontinalis flaccida Ren. & Card. Collected by Lesquereux, no other locality data available.

Fontinalis novae-angliae Sull. Caldwell, Harlan, Letcher, Madison, McCreary, and Wolfe counties.

Fontinalis novae-angliae var. *cymbifolia* (Aust.) Welch. Whitley County.

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FANG LENGTH COMPARISONS OF AMERICAN AGKISTRODON

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Klauber (1939) initiated the study of American pit viper fangs with a complex, satistical study of *Crotalus* and *Sistrurus* dentition. Fitch (1960) examined a small number of copperhead fangs, but very little study of *Agkistrodon* fangs had been done until the author undertook a study of the fang lengths of nearctic *Agkistrodon* (Ernst, 1963). This article is a portion of that study. Few papers dealing with the comparative sizes of snake's fangs are available. Besides Klauber's report on rattlesnakes (1939), there is Bogert's report on cobras and other elapids (1943), both of which have been used for comparison in this study.

Klauber (1939) points out that the length and character of the fangs of poisonous species present a study of some practical interest, since they involve several of the variables which affect the results of snakebite, such as the depth of penetration of the venom, the rapidity of injection, the amount of venom which may be lost externally in clothing, and the chance of fang breakage in contact.

In this study, the following comparisons have been made between the species and subspecies considered: mean fang lengths, the relationship of mean fang length to total body length, and the relationship of mean fang length to head length. The total body length is used as a datum for comparison with fang length since it was also used in the above studies. Klauber also used head length as a comparative measurement as I have.

Materials and Methods

This study is based principally on data derived from 342 specimens of the genus *Agkistrodon*. Specimens examined are from the United States National Museum, the American Museum of Natural History, the Carnegie Museum, the Academy of Natural Sciences of Philadelphia, Millersville State College, and the author's personal collection. The numbers of snakes measured were: *A. bilineatus* 21, *A. contortrix contortrix* 69, *A. c. laticinctus* 32, *A. c. mokeson* 100, *A. c. pictigaster* 4, *A. piscivorus leucostoma* 52, and *A. p. piscivorus* 64.

In measuring the total body length, the snake was stretched out as straight as possible beside a tape measure and the length measurement was read directly from the tape measure. When the snake could not be stretched, a string placed along the length of its backbone was measured. Vernier calipers were employed to measure the total head length from the tip of the snout to the point where the cervical vertebrae begin. This point is quite noticeable in *Agkistrodon* and in the rattlesnakes, but not in elapids, as Bogert (1943) points out.

The straight-line distance from the lower end of the entrance lumen to the tip of the fang as a basis of length has been adapted here. Measurements of fangs were made under a dissecting microscope with Vernier calipers. Both edges of the calipers were ground to accommodate the head portion of a straight pin fastened to each point of the calipers. One of the these pins was inserted into the entrance lumen and the other brought up until it touched the lower tip of the fang. This gave an accurate measurement of the straight line between these two points. In order to measure a fang, the membranous vagina dentis had to be pushed out of the way. Usually it was impossible to slide this covering from over the fang, in which case the vagina dentis was dissected away. Both fangs, and where possible the completed first reserve fang, were measured.

Results and Discussion

Klauber (1939) has shown that the head length, rather than that of the body, constitutes the better basis for comparison during the adult stage. In vertebrates, generally, the size of the head is proportionally larger in juveniles and smaller in adults in relation to body length. Klauber (1938) confirmed the relationship on rattlesnakes and the findings on *Agkistrodon* species are in accord with this general rule. The fangs are also larger in relation to head and body length in juveniles. This situation becomes reversed as the snake grows in head and body length, since the fangs do not grow at a steady rate in comparison to body or head growth.

Included in table 3 are mean head lengths and mean head/mean fang ratios. *A. bilineatus* was found to have the largest fang range in comparison to mean head length and the lowest mean head/mean fang ratio, indicating that on an average it has the largest fangs of the American *Agkistrodon*. The four subspecies of *A. contortrix* show a variation of only 0.2 in this ratio indicating a very close resemblance as to fang size. The two subspecies of *A. piscivorus* show a variation of only 0.1 in the mean head/mean fang ratio. The small variations reported here tend to substantiate the subspecific relationships found in *A. contrortrix* and *A. piscivorus*.

Comparing the Agkistrodon ratios to those given by Klauber (1939) for rattlesnakes, it is found that only *A. bilineatus* has fangs that compare in length to most rattlesnakes. Rattlesnakes of the genus *Crotalus* have proportionally longer fangs than *Agkistrodon.* Klauber measured five *C. adamanteus* and found them to have a head length of 59.1 mm. and a mean head/mean fang ratio of 4.13. Only *C. tigris, C. lepidus klauberi, C. t. triseriatus,* and *C. t. pricei* had ratios above six and could be compared with *Agkistrodon.* Even the smaller *Sistrurus* had lower ratios than *Agkistrodon.* Table 1 shows the increase in mean fang lengths between *Agkistrodon* on a basis of head length.

Table 1. A comparison of Mean Fang Lengths Between Species On a Basis of Head Length.

	Fang Length in mm.						
Head Length in mm.	bili-neatus	c. con-tortrix	c. lati-cinctus	c. mokeson	c. picti-gaster	p. leuco-stoma	p. pisci-vorus
10		2.3	1.1	1.8			
15	3.7	2.2	2.0	2.1		2.3	
20	4.8	3.6	3.4	3.4	3.4	3.8	3.7
25	3.8	4.1	4.5	4.7	4.3	4.7	4.2
30	7.0	5.1	4.6	4.5	4.4	5.1	5.0
35	7.3	5.2		5.2	5.5	6.1	6.1
40	8.4	5.5	5.2	6.5		6.6	6.4
45	9.3					7.5	7.4
50	9.9						9.4
55	10.1						10.3
60						10.5	10.4

A skull of a *Naja naja* was examined for comparison. The skull was 36.2 mm. in length and the fangs were 4.5 mm. long. This gave a mean head/mean fang ratio of 8.04.

There has always been interest in calculating the ratios of total body length divided by fang length in venomous snakes. In examining such a ratio, it is found that specimens having longer fangs have lower ratios. (See table 3). *A. bilineatus* shows a mean body/mean fang ratio of 90 for the lowest ratio. *A. c. contortrix* is shown to have the highest ratio with 145. *A. p. leucostoma* and *A. p. piscivorus* are extremely alike in their fang measurements and ratios. Table 2 shows the increase in mean fang lengths between *Agkistrodon* on a basis of body length.

By examining figures given by Bogert (1943) for elapids and Klauber (1939) for rattlesnakes, it is found that the American *Agkistrodon* fall between these two groups in relation to mean body/mean fang ratios. The elapids have higher ratios and therefore shorter fangs in relation to body length. The range in Bogert's elapids was from 232 for *Naja naja* (northern India) to 591 for *Toxicocalamus stanleyanus. Ophiophagus hannah* had a ratio of 381. The rattlesnakes had generally lower ratios than *Agkistrodon.* The range in *Crotalus* was from 80 for *C. stejinegeri* to 165 for *C. tigris,* and in *Sistrurus* from

108 for *S. ravus* to 131 for *S. c. catenatus*. The nearctic *Agkistrodon* did have lower ratios than *C. tigris* (165), *C. m. mitchelli* (151), *C. v. klauberi* (162) and *C. t. pricei* (155).

Table 2. A Comparison of Mean Fang Lengths Between Species On a Basis of Body Length.

Body Length in mm.	bilineatus	c. contortrix	c. laticinctus	c. mokeson	c. pictigaster	p. leucostoma	p. piscivorus
100			1.1	1.6			
200	3.5	2.1	2.0	2.1		2.4	
300	4.2	3.2	3.4	2.6		3.4	3.5
400	3.8	3.8	3.8	3.7	3.4	4.6	4.2
500		3.6	4.5	4.2	4.4	5.5	4.8
600	7.2	4.1	4.6	4.6	5.5	6.1	6.0
700	7.5	4.6	5.4	5.5		5.9	6.2
800	8.5	5.3	5.0	5.6		6.0	7.2
900	9.4	6.3		5.7			8.0
1000	10.4	5.5				7.5	9.4
1100		7.0					10.2
1200						10.5	9.9
1300						10.4	11.0

A comparison of mean fang length again indicates the *Agkistrodon* fall between the elapids and rattlesnakes. *A. bilineatus* with a mean fang length of 7.5 mm. has the longest fangs of the nearctic *Agkistrodon*. *A. c. laticinctus* had the smallest mean fang length of 4.2 mm. The mean fang length of 4.4 mm. for *A. c. pictigaster* is not a true indication of the fang length in this subspecies because of the small number of specimens examined (see table 3).

Table 3. Fang Proportions in the Genus Agkistrodon

Species	Number of Specimens	Body Length Range	Fang Length Range	Mean Body	Mean Head	Mean Fang	Mean B/F	Mean H/F
A. bilineatus	21	213-1016	3.4-12.0	678	36.1	7.5	90	4.8
A. c. laticinctus	32	170- 800	1.1- 5.6	528	28.3	4.2	126	6.7
A. c. contortrix	69	229-1100	1.5- 7.0	567	26.0	3.9	145	6.7
A. c. mokeson	100	178-1000	1.1- 7.0	524	25.9	3.8	135	6.8
A. c. pictigaster	4	400- 673	3.4- 5.5	555	29.2	4.4	126	6.6
A. p. leucostoma	52	200-1350	1.7-10.5	509	29.8	4.5	113	6.6
A. p. piscivorus	64	305-1300	3.0-11.0	663	38.6	5.9	112	6.5

Bogert (1943) shows that some of the longer elapids, such as *Dendroaspis* and *Ophiophagus hannah*, have larger mean fang ratios than do *Agkistrodon*, but size is a factor here. In the size range corresponding to that of *Agkistrodon*, these snakes have shorter fangs. *Naja naja*, *N. haje*, *N. melanoleuca*, *Pseudohaje nigra*, and *Hemachatus haemachatus* have mean fang lengths that fall within the range of American *Agkistrodon*, however, most elapids have smaller fangs.

Micruroides euryxanthus has a mean fang length of only 0.8 mm. and *Micrurus fulvius* 2.3 mm. These two elapids, which occur in the United States, have smaller fangs than do the pit vipers studied. Fairley (1929 states that the fangs of *Acanthophis antarcticus* average 6 mm., *Denisonia superba* 3 mm. and those of *Notechis scutatus* 3 to 5 mm. in length. *Ophiophagus hannah* has the largest fangs of elapids. Bogert reports a specimen 3055 mm. long having fangs 8.0 mm. in length. Klauber (1939) believes that an 18 foot (5490 mm.) king cobra would have fangs about 15 mm. long. The mean fang length range of Bogert's elapids was from 0.7 mm. for *Ultrocalamus preusii* to 8.0 mm. for *O. hannah.*

Most of Klauber's rattlesnakes (1939) had longer mean fang lengths than did the *Agkistrodon* measured. Their mean fang lengths ranged from 3.4 mm. for *C. lepidus klauberi* to 14.4 mm. for *C. adamanteus.* The longest rattlesnake fang measured was 15.8 mm. in *C. adamanteus.* The longest *Agkistrodon* fang was 12.0 mm. in *A. bilineatus.*

Barton (1950) found the functional fang length in two newborn *C. h. horridus* to be 3.2 mm. and 3.3mm. These snakes were 289 mm. and 268 mm. in total length. Fitch (1960) points out that the young of the copperhead are also slightly longer than 200 mm. at birth. Most juvenile *Agkistrodon* between 200 and 300 mm. in body length had shorter fangs than Barton's specimens, although *A. bilineatus* did reach this size (see table 2). Barton reported replacement fangs in his rattlesnakes ranging from 3.1 mm. for first reserve fangs to 2.0 mm. for third reserve fangs. Several near term copperhead embryos contained replacement fangs, but these were shorter than *C. h. horridus.* An *A. c. laticinctus* 170 mm. in length had functional and first reserve fangs of 1.1 mm. and embryos of *A. c. mokeson* 178 mm. and 150 mm. long had functional fangs of 2.0 mm. and 1.1 mm. and first reserve fangs of 1.9 mm. and 1.1 mm. respectively.

Using the total length as a guide for comparison, there is little doubt that vipers of the genus *Bitis* exceed all other living snakes in fang length. Bogert (1943) reports a series of ten *B. arientans,* ranging in size from 743 mm. to 995 mm., had fangs 9.7 mm. to 14.3 mm. in length, with body/fang ratios of 60 to 83. In fang size *B. gabonica* exceeds all other snakes. Stanley (1929) reports a specimen as having fangs 30 mm. in length and Bogert (1943) another 1300 mm. long as having fangs 29 mm. in length. Bogert states that snakes of the genus *Causus* have, in proportion to total length, the smallest fangs of any viper he examined. Twenty-one Angolan specimens of *C. rhombeatus,* which ranged in size from 190 to 590 mm., had fangs which ranged in length from 1.1 to 2.6 mm. The body/fang ratios of these snakes ranged from 158 in juveniles to 245 in adults.

Summary and Conclusions

Examination of the 349 *Agkistrodon* used in this study has revealed certain conclusions as to their comparative fang lengths. Data on fang proportions of American *Agkistrodon* indicates that *A. bilineatus* has the longest mean fang length and also the lowest ratios of head/fang and body/fang. *A. p. leucostoma* and *A. p. piscivorus* were found to be almost identical in their head/fang and body/fang ratios. In the head/fang ratio there was only 0.1 difference between these snakes and in the body/fang ratio the difference was only 1.0. The four subspecies of *A. contortrix* show a variation of only 0.2 in the head/fang ratio. Fang characters and other dentitional differences are often correlated and provide useful information in connection with taxonomic and phylogenetic interpretations. The small variations reported in head/fang and body/fang ratios tend to substantiate the subspecific relationships found in *A. contortrix* as well as *A. piscivorus*. The information presented appears to show that the nearer such ratios approach each other the more closely related the members of the genus.

The fang proportions of *Agkistrodon* were found to be located between the rattlesnakes measured by Klauber (1939) and the elapids measured by Bogert (1943). Only *A. bilineatus* could compare favorably in fang proportions with the larger-fanged rattlesnakes. The elapids *Dendroaspis* and *Ophiophagus hannah* have larger mean fang lengths than American *Agkistrodon*, but these snakes attain a longer body length. In the size range of American *Agkistrodon* these snakes have shorter mean fang lengths. *Micrurus fulvius* and *Micruroides euryxanthus*, which occur over much of the range of *Agkistrodon*, have much shorter fangs. It should also be noted that the vipers of the genus *Bitis* exceed all other living snakes in fang length, and *B. gabonica* has the largest fangs of any living snake reaching a length of 30 mm.

It was found that replacement fangs are fully developed in near term copperhead embryos, although these and the functional fangs were shorter than those reported by Barton (1950) for newborn *Crotalus h. horridus*.

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THE BACULUM IN MYOTIS SODALIS AND MYOTIS AUSTRORIPARIUS AUSTRORIPARIUS

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Hamilton (1949:97) summarized the earlier literature on the study of the os penis in the Chiroptera and described the bacula of 14 species in the Family Vespertilionidae. Krutzsch and Vaughan (1955:96) described an additional 11 bacula in North American vespertilionids, plus the baculum in the molossid *Tadariada brasiliensis mexicana*. The baculum has been figured for 8 species of North American *Myotis*, excluding *Myotis sodalis* and *Myotis austroriparius*. Therefore, the purpose of this paper is to make such description for these two species of *Myotis*.

The individuals used in this study were adults, as determined by the closed ephiphyses of the metacapal and phalangeal joints. The following descriptions are based upon the examination of 12 specimens of *Myotis sodalis* and 11 specimens of *Myotis austroriparius austroriparius*. The line drawings in Figure 1 depict individual as well as possible age variation.

Myotis sodalis—The baculum is saddle-like; the bone appears to be flexed and has a slight dorsal knob at the distal end. The proximal portion rises abruptly from the saddle, and a basal as well as a ventral groove is present. When viewed ventrally, the bone appears arrow-like.

Myotis austroroiparius austroriparius—The baculum is slipper-like; the bone is nearly straight in profile. The proximal portion is peaked; the distal and is blunt and rounded. A very slight basal groove is present, and the bone is grooved ventrally. When viewed ventrally, the bone appears broad and blunt.

The bacula of these two species were compared with those of *Myotis lucifugus lucifugus*, *Myotis keenii septentrionalis*, *Myotis grisescens*, *Myotis velifer velifer*, and *Myotis velifer incautus*. The baculum of each species is distinct; however, certain similarities were noted in the structure of the bacula of *Myotis velifer-Myotis grisescens* vs. *Myotis austroriparius*. It would, however, be presumptive to make evolutionary inferences at the species level on the basis of the baculum alone.

Acknowledgements

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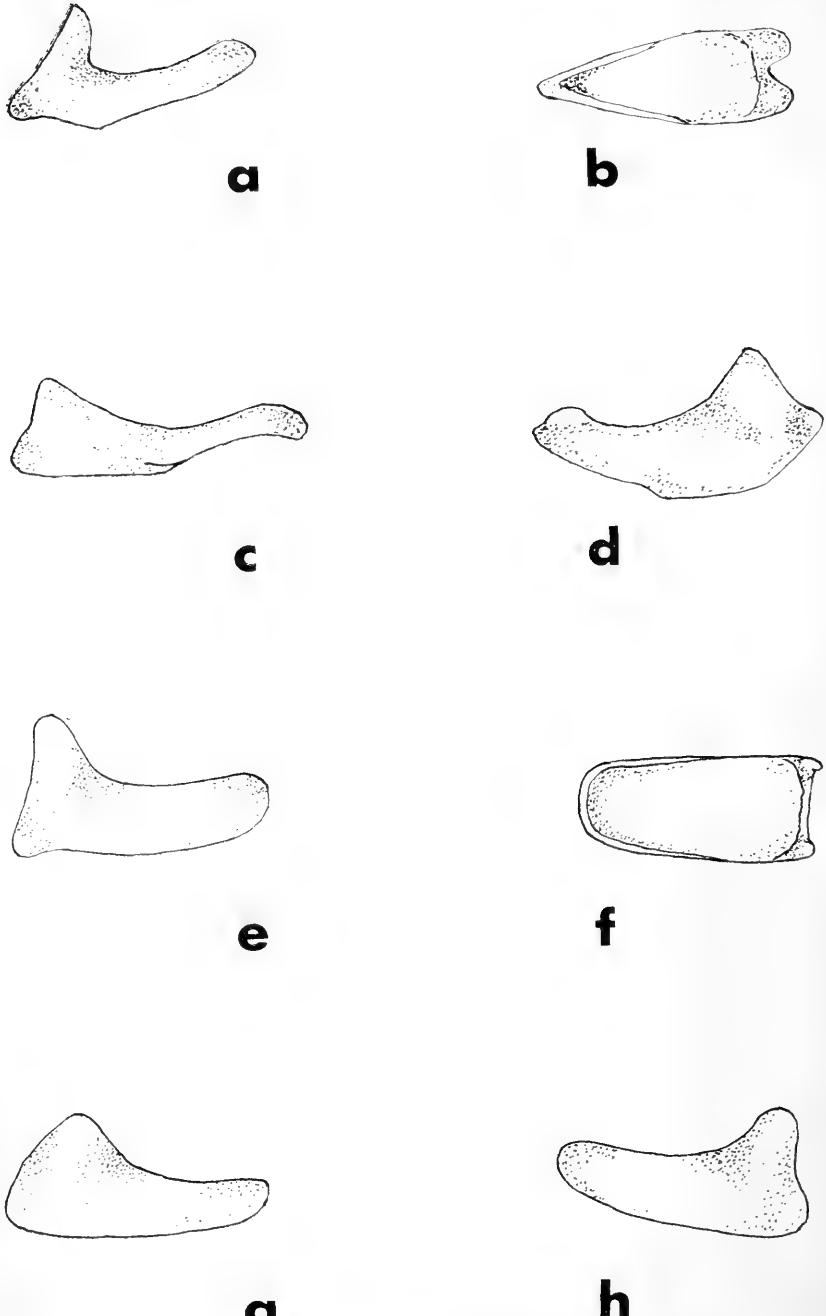

Fig. 1. — a, c, d lateral views of *Myotis sodalis*, b ventral view *Myotis sodalis*. e,g,h lateral views of *Myotis austroriparius*, f ventral view *Myotis austroriparius*.

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SKETCHES FROM KENTUCKY'S BEEKEEPING HISTORY

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Introduction

Honey bees are not native to this continent but were introduced in the seventeenth century by Dutch settlers arriving at Nieuw Amsterdam. Soon after their arrival, absconding swarms established themselves in the forests. Honey bees, which are mankind's most beneficial insect, were termed the heralds of American civilization, since they were always in advance of the inland and westward movement of the first white settlers.

The history of beekeeping events in Kentucky can very definitely be divided into four distinct periods, or eras, which as as follows: Events occurring between 1780 and 1871 mark the "beginning" period or Era I. A brief description of these early days is given by George W. Demaree in his "History of Agriculture in Kentucky." It is as follows: "Kentucky in her early history was famous on account of her wonderful forests. In those days many persons kept bees in tall log gums and boxes, and the bees succeeded in propagating the species and bearing up under the disadvantages imposed upon them by their ignorant keepers in a manner which would put the best of the races to blush under like treatment at the present day. The reasons for this I have already given, an abundance of poplar and linden, etc. were at their service."

Dr. N. P. Allen of Smith's Grove, Warren County, ushered in Era II (1872-1913) when he introduced the Italian race of bees into Kentucky in 1872. Dr. Allen gives a very good description of this period in an article titled "Cultivation of the Honey Bee." He says: "If I could go back to the palmy days of bee culture in Kentucky, in '74 to '82, '83 and '84 when we had hundreds and thousands of colonies of bees over this Southern Kentucky and bee forage was plentiful, rich and inexhaustible, when white clover covered the road-sides, the waste places and often the pasture fields like a carpet of snow in the winter time; as I said, if I could go with you back to such times as to bring them up to the present and fill the forests with rich forage in the poplars, maples and other forest trees that have fallen by the woodsman's ax; yes, and could fill the air with sweet fragrances from nectar cups in the clover blooms in our fields and pastures, if I could do that I could awake some interest and enthusiasm in rational beekeeping." Those days were known as the "new way" and Pellett calls it the "golden age in beekeeping," since there was keener interest in undertaking to master the fundamentals of beekeping during this priod than at any other time.

Era III (1914-1959) may be summarized as being an "uncertain" period, during which time beekeepers were hard-pressed to keep beekeeping alive in a changing age of farming practices and economic developments; however, several important advances were initiated. The highlight of this period may well be the diligent fight which the State Association carried on for full-time disease control. With the realization of this goal in 1960, Era IV was ushered in, which may come to be known as the true "development and unifying" period in Kentucky's beekeeping history.

In order that the following chronological sketches from Kentucky's colorful beekeeping history can be more easily understood, as well as introducing several of our outstanding beekeepers, it is necessary that we should establish four revolutionary dates as a background for our comparative thinking. These dates represent developments which were of major importance to beekeepers throughout the world, in fact, it was through these discoveries that a whole new industry was born. They are briefly discussed as follows:

1. The miraculous discovery of the bee-space and the resulting development of the movable-comb, top-opening hive by Rev. L. L. Langstroth, Philadelphia, Pennsylvania, in 1851. This discovery marked a definite turning point in the history of beekeeping the world over.
2. The invention of comb foundation must be credited to a German, Johannes Mehring, who first succeeded in producing a crude product in 1857.
3. Major Franz von Hruschka, Vienna, Austria, is credited with the development of the centrifugal extractor in 1865.
4. The other discovery of major importance came in 1875 when Moses Quinby, New York, invented the first practical bellows-type smoker.

Summary of Events

Era I (1780-1871)

1780 Bees were introduced into the area which is now the state of Kentucky by Col. James Harrod. Col. Harrod brought one colony of bees from Pennsylvania to the Falls of the Ohio, the present-day location of the City of Louisville.

1869 1. General D. L. Adair (1824-1904), Hawesville, Hancock County, received a patent for his section bee hive, which had a surplus chamber made by fitting a series of sections together, nine in a clamp. Each section was 5x6x1½ inches. This patent seems to have met with favor, and for a time Adair sold rights for use to individual beekeepers with one sample section for $3.00. He also developed an extractor which was one of the first to be offered for sale commercially. (See Fig. 1). In addition to these items, Adair developed a queen and drone trap, a triangular queen cage, and a division-board type feeder. He also reared and sold queen bees, shipped bees by the pound on established combs in a nucleus hive, and published books and

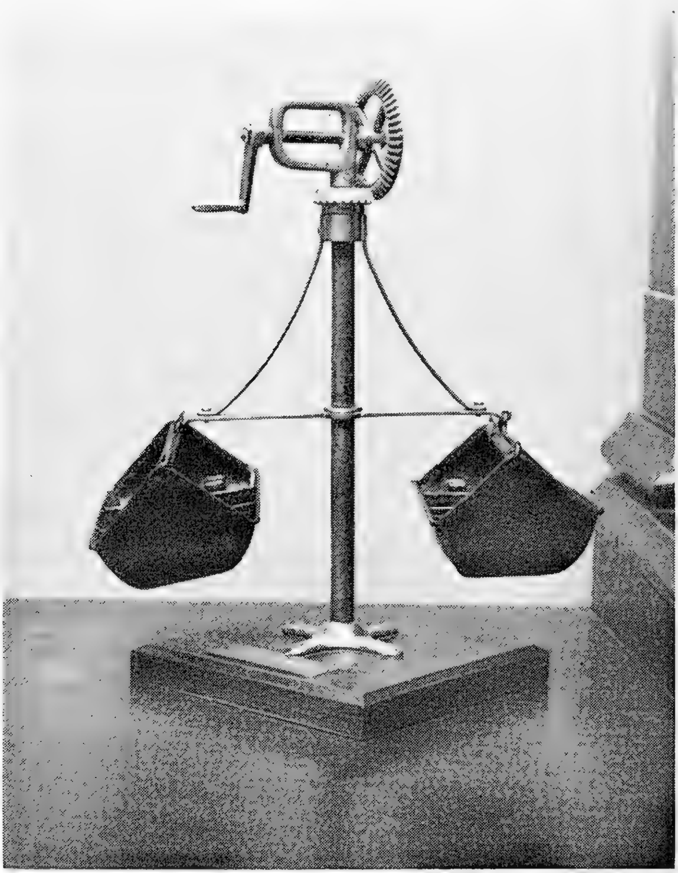

Fig. 1. — General D. L. Adair's extractor, which was called the "Meliput," was one of the first to be offered for sale commercially throughout the states.

pamphlets on a variety of beekeeping subjects, the most important being several volumes entitled "Annuals in Bee Culture."
2. Charles Tinius, Cloverport, Breckinridge County, an early manufacturer of supplies for beekeepers, who probably made the section hive and other items for Gen. Adair, advertised a variety of beekeepers' supplies for sale.

Era II (1872-1913)

1872 1. Introduction of Italians into Kentucky by Dr. N. P. Allen (1830-1909), a dentist from Smith's Grove, Warren County. Dr. Allen headed a committee of seven fellow beekeepers whose interests were to provide a better race of bees for the beekeepers of the state. Th committee was composed of the following men: Dr. Dillard, Lexington; Rev. McGee, Anchorage; Capt. S. T. Drane, Shelby County; John Conley, Gallatin County; A. C. Tucker, Gen. Adair and Dr. Allen. The price of queen bees was around $15.00 each.

2. Dr. William M. Rogers, Shelbyville, Shelby County, purchased several imported Cyprian queens. His friend, George W. Demaree of nearby Christiansburg, assisted him in rearing seven queens from these imported mothers. Mr. Demaree said: "I have reason to believe that they were the first ever to be reared in Kentucky."

1874 Organized beekeeping was begun in Kentucky at the regional level with the organization of the Southern Association by Dr. N. P. Allen, who was elected as the Association's first president. (Fig. 2)

1879 1. J. P. Moore, of Morgan, Pendleton County, began queen rearing activities which brought considerable recognition to the Kentucky queen breeder in 1900. Mr. Moore was awarded the $25.00 prize, which was offered by the A. I. Root Company, Medina, Ohio, for having developed the longest tongued strain of bees. The record tongue reach of Moore's three-banded, leather-colored Italians was 23/100 inches. As a result, "Moore's Strain of Italians" became widely known for their superior honey-gathering characteristics, as well as having outstanding hardiness and gentleness qualities. Mr. Moore operated the Cedar Lake Apiaries at Morgan.

2. E. E. Barton, Falmouth, also in Pendleton County, made history during the latter part of this Era by introducing what was generally called an "obnoxious weed" into the area, in one

Fig. 2.— Upper left, Dr. P. N. Allen; upper right, Prof. Harrison Garman; lower left, George W. Demaree; lower right, E.E. Barton.

of the first efforts at crop rotation. The "weed" was sweet clover, which later provided farmers throughout several northern Kentucky counties with a land literally "flowing with milk and honey." The dairymen and beekeepers of the area had acquired a new lease on life through the benefits derived from their greatly improved soils.

1880 1. The Kentucky State Beekeepers' Association was organized at Louisville with Dr. N. P. Allen as its first president. During the same year he was elected president of at least two national beekeeping organizations. Organizational dates of other state associations by comparison were: Iowa – 1875 and North Carolina – 1890 (possibly 1887).

2. During the early 1880s J. S. Reese of Winchester, Clark County, developed the industry's first bee escape, through his application of the principle involved in the simple, old-fashioned fly trap. This practical, though somewhat cumbersome device, was sold to an unidentified man for $25.00, after some additional refinements by Reese. This man was probably John A. Larabee, who, after further development, sold the escape then known as the LaReese to E. C. Porter of Lewistown, Illinois. The bee escape in its present form bears the Porter name. The Reeses, father and son, Wallace, obtained high colony averages (200 pounds) during these years by using migratory practices. They operated as many as 425 colonies for several years until foulbrood hit the area, wiping out the life's earnings of several beekeepers almost overnight.

3. C. E. Bowman, Commissioner, Kentucky Bureau of Agriculture, Horticulture and Statistics, placed an evaluation of $12,000,000 on the contributions which the beekeeping industry made annually to the state's over-all economy. This evaluation, which was presented by the Commissioner in his Biennial Report to the Governor of the Commonwealth, was based upon the following calculated statistics: "If Kentucky were to be laid off in 5-acre plots, there would be largely over 4,000,000 plots. With an estimated one bee-stand to each plot, furnishing one swarm worth two dollars each season, and producing one cap weighing 20 pounds of surplus honey, at 20c a pound, would give a value of six dollars per hive." This gives the outstanding figure of $24,000,000 as an evaluation of the comparatively small industry. In further discussion an allowance was made for crop failure during alternate years, resulting in the annual evaluation figure of $12,000,000. Thus, honey bees were highly regarded as an important link in the agricultural prosperity of the state during the early development years of the industry.

1881 Mr. William Williamson, secretary, offered the following resolution at the second annual meeting of the Kentucky State Beekeepers' Association, which was held at the Exposition Building in Louisville. "Resolved, by the Kentucky State Beekeepers' Association, that in order to educate the youth of our state and the country at large in the noble science of bee culture, that we recommend to the President and Board of Directors of the State Agricultural and Mechanical College a department in apiculture, and that an apiary be established at the college grounds in Lexington; that lecture be given to the students, and practical lessons in apiculture be given to the students; that a committee is hereby appointed to confer with the President and Directors of our State College." The resolution was adopted and the following committee was appointed: William Williamson, G. W. Demaree, and Dr. L. E. Brown.

1884 George W. Demaree (1832-1915), Christiansburg, Shelby County, wrote a pamphlet titled: "The History of Apiculture in Kentucky." This informative work was written from reports received from the state's leading beekeepers, through correspondence and visitation. A portion of the Introduction to this work says: "If this little work shall help only a few persons in and out of our state in their search for good locations for the culture of the honey bee and the production of honey, and shall prove the initial step to more extensive knowledge in this behalf, the committee will feel that they have not labored in vain." The better locations were considered to be in those counties bordering on the larger water courses. Mr. Demaree was assisted by three other members of the Association in this endeavor; they were: Dr. N. P. Allen, Smith's Grove; W. C. Pelham, Maysville, Mason County; and J. T. Connley of Napoleon, Gallatin County.

1886 1. "SECTIONS AND BERRY BASKETS. We, the original inventors of the one-piece sections are now prepared to furnish sections and berry baskets in any quantity. Please write for terms. M. & H. F. Coffin, Milton, Trimble County, Kentucky." This ad appeared in the April 14, 1886, issue of the AMERICAN BEE JOURNAL.

2. Beekeepers and horticultural groups often combined their efforts during the early days, as the following information bears out. "To the premium lists of the Horticultural Exposition of 1886, at the Louisville Exposition Center, including also various kinds of honey bees and their products, I contributed $168.00 on the part of the state," reported Agriculture Commissioner John F. Davis in the biennial report published during the year.

He further reported that "the event was well managed, and passed off to the entire satisfaction of all concerned."

1887 In an article titled, "Bee Culture, Its Progress, etc.," which was used in the Commissioner's Report to the Governor for this year, George W. Demaree says: "Kentucky is behind some of the other states in the repoduction of honey, because of the tardiness of our people to embark in new enterprises—especially enterprises which seem small—"little"—to them. I think this is a mistaken notion. What we need most is less "big" failures and more "small" successes; and this we must have by utilizing a great variety of occupations. No state in the Union can produce honey of finer quality, density, color and flavor—than the honey of Kentucky . . . and no place on this continent is better adapted to the rearing of finely-developed honey bees than is Kentucky. The same favorable conditions which contribute to the rearing of fine stock in Kentucky, has its influence in the development of bee life and bee activity under proper laws of breeding."

1889 1. Professor Harrison Garman began his official duties as entomologist and botanist at the Kentucky Agricultural Experiment Station, which extended over a period of forty (40) years. (See Fig. 2.). During this time he made many contributions to the field of economic entomology, worked with the State Association, and contributed several articles of practical value for beekeepers of the state. He is described by close associates as being an "old-fashioned naturalist." He also taught a class in beekeeping which had small enrollment at the time. His beekeeping books are now housed in several Lexington libraries.

2. The newly-devised equipment of two Kentucky beekeepers was exhibited at the World's Exposition which was held at Paris, France, in 1889. George W. Demaree, Christiansburg, contributed a solar wax extractor and a modernized Langstroth-type hive, which used an improved slotted top-bar frame, to the U. S. portion of the exhibit. J. S. Reese, Winchester, contributed a queen and drone trap and the original bee escape to the world-wide show. This equipment was donated to the U. S. government following the Exposition to be placed in an agricultural museum in Washington, D. C. (Author's note: To date, no trace of these valuable antique pieces of equipment has been found.) Prof. Nelson W. McLain, apicultural agent for the USDA, was in charge of the Exhibition.

1892 George W. Demaree announced his now-famous swarm conrtol plan, which he revised two years later. (See Fig. 2). He served as secretary and as president of the State Association, several years in each capacity. It is through his efforts that we are privileged to have an account of the early days of Kentucky's beekeeping. He also developed the solar wax extractor in its improved form. For a detailed account of his fruitful and interesting life as apiarist, lawyer and essayist, read my article titled: "Beemaster—Not Just a Beekeeper," in the December, 1956, issue of the AMERICAN BEE JOURNAL, pages 472-477, illustrated.

1893 1. This was a period of little interest and activity. It was partially due to the fact that the price of honey had dropped to 3c per commercial pound. Also, interest in travel and the "new way" had waned, and the leveling off period brought little interest in the conventions or activities with other beekeepers, as had been true earlier. Two Pendleton countians, however, made history at the turn of the century for their contributions to the state's beekeeping industry. They were: J. P. Moore, a queen breeder, who developed the strain of long-tongued bees, and E. E. Barton, a lawyer-beekeeper, who pioneered the introduction of sweet clover into the area. (See 1879 for further details.)

2. An Act "to provide for county inspectors of apiaries and defining their duties and providing for their compensation for the purpose of curing and avoiding foulbrood and other diseases among bees and their hives" was approved by the General Assembly March 23, 1910. An annual tax of 5c per colony was to be levied to carry on the inspection service at the county level, with the fee being collected by the sheriff of each county. This law was later declared unconstitutional and another bill was passed, however, it was also declared unconstitutional due to improper titling . (Author's note: We now operate under the 1922, or the original law, with amendments being made in 1948 and again in 1960.)

Era III (1914-1959)

1914 Although organized beekeeping has existed in Kentucky since 1874, it was not until January 9, 1914, that the State Beekeepers' Association adopted a constitution; the by-laws were re-written in 1949. The purpose of the organization was given by its leaders as follows: "Its objects shall be in forming of a bond of union among Kentucky beekeepers and the improvement of its members in both scientific and practical apiculture by an exchange of experiences and the discussion of beekeeping methods." Thus this reorganization date bridges the gap between the "new way" and the Era III.

1915 E. E. Barton, of Falmouth, declared that Kentucky had advanced to third or fourth position in the value of its apiary products with a honey crop estimated at 5,000,000 pounds. Pendleton County alone produced 500,000 pounds, this being essentially from sweet clover, which Barton had introduced into the area in an effort to combat the soil erosion problem that had existed since Civil War days. (See Fig. 2.)

1916 The name "John A. Sheehan" was synonymous with the production and sale of choice honey from Pendleton County for many years. In his article titled, "Honey Production," which was printed in the Biennial Report for 1916-1917, Mr. Sheehan listed the following facts concerning his beekeeping operations. They were: (1) He carried a full line of Falconer's beekeepers supplies; (2) Honey was shipped all over the U.S. in cases and sanitary cans, 90% of which was produced from sweet clover; (3) He sold both white and yellow sweet clover seed; (4) Pendleton County was known as the "home of sweet clover," and beekeepers there produced more choice honey than any other county in the world, with the amount being more than 500,000 lbs. annually. This brought county beekeepers approximately $50,000 each year. The exceptionally high yielding seasons along with higher prices yielded around a reported $75,000; (5) In addition, several thousand dollars worth of queen bees were sold by Pendleton County breeders, who were recognized as being among the main breeders of the industry.

1917 Circular 17, "Foulbrood of Bees; Its Recognition and Treatment," by H. Garman published by the Kentucky Agricultural Experiment Station.

1919 Extension Circular 69, "Elements of Beekeeping," by H. R. Niswonger published by the Agricultural Extension Service, College of Agriculture, University of Kentucky.

1922 Kentucky's initial Apiary Inspection Law was enacted during the regular session of the General Assembly. The purpose of the Act was "to provide for the suppression of contagious diseases among bees; to create the office of State Inspector of Apiaries; and to appropriate money therefor," These duties were assigned to the State Entomologist, Kentucky Agricultural Experiment Station, Lexington.

1925 Circular 35, "Beekeeping for Beginners," by H. Garman published by the Kentucky Agricultural Experiment Station.

1929 Professor W. A. Price came to the University of Kentucky as Head of the Department of Entomology and Botany and served in this capacity until his retirement in 1957. Beginning in 1930, he was instrumental in reviving the State Association and in having an annual meeting at the University in connection with the Farm and Home Week proceedings. He served as secretary of the Association until this office was moved to Louisville in 1944. Professor Price held beekeepers' meetings throughout the state, and taught a one-semester course in beekeeping until 1937, wen Dr. Lee H. Townsend was assigned this teaching job. Enrollment in these classes was always good and interest in the classes and meetings was high. During these years an apiary of sixteen to twenty colonies was kept on the campus, and the state's only inspection service was carried on by Professor Price. This service was limited to the inspection of queen rearing yards and to the shipment and movement of bees into and out of the state. Since the work which Professor Price advocated and accomplished was for the advancement of the state's people, it is regrettable that his requests for funds for an extension worker in beekeeping were always met with sympathetic ears but no action.

1930 Reoganization of the State Association under the leadership of Prof. W. A. Price, of the College of Agriculture, with annual meetings being held in connection with the Farm and Home Week proceedings until 1944, at which time the Association was moved to Louisville for all its activities.

1934 The Walter T. Kelley Company, manufacturers of quality beekeepers' supplies at highly competitive prices, was moved from Louisiana to Paducah. Mr. Kelley is the author of two well-written, practical books for beekeepers. They are: "How to Grow Queens" and "How to Keep Bees and Sell Honey." Also, he edited and published the popular magazine, "Modern Beekeeping," for several years. This firm has supplied beekeepers on five continents with quality supplies for nearly three decades, and has truly made the phrases: "Made in Kentucky, U.S.A." and "Eat Honey, Feel Better, Live Longer" famous.

1936 Dr. Lee H. Townsend came to the University of Kentucky as instructor in the Department of Entomology and Botany. Beginning in 1937, he taught the one-semester course in bee-keeping and assisted in maintaining the college apiary.
Dr. Townsend served the Association as Judge of Apiary Products at the State Fair for several years, and assumed duties as Head of the Department in 1957 when Professor W. A. Price assumed change-of-work status.

1937 Circular 288, "Beekeeping in Kentucky," by Professor W. A. Price was published. This work was revised in 1949.

1944 The meeting place for the State Association body was changed from the University to Louisville, with meetings being held on a monthly basis rather than annually, as had been the custom. This movement was initiated by several of the charter members from Louisville, dating from the 1914 reorganizational date. Interest in beekeeping during these years varied immensely as the various references to "revivals" will indicate.

1945 Walter T. Kelley purchased the popular beekeeping magazine known as THE BEEKEEPER'S ITEM from E. G. LeSturgeon San Antonio, Texas, around 1945. Kelley continued publication of the magazine, using the name of MODERN BEEEKEEPING, until May, 1956.

1948 Passage of the state's Bee Law creating the office of State Apiarist with "legislation designed to promote and encourage the bee industry through registration of all bee colonies and having as its main objective the elimination and control of bee diseases." The Commissioner of Agriculture was given the duty of enforcing this newly-created Bee Law.

1949 The year 1949 was a profitable one for beekeeping in Kentucky, since several important acts were initiated. These events were: (1) Commissioner of Agriculture, Judge Harry F. Walters, appointed five inspectors to initiate an apiary inspection service for the control of bee diseases; (2) Fred O. Miller of Louisville, who was often referred to as the "Louisville Bee Master," toured the state with an educational trailer, provided by State Association funds, giving promotional demonstrations at the various county fairs. He was successful in promoting the Association and the industry as a whole for several years; (3) The Honey Show was reinstated at the State Fair and special emphasis was devoted by members of the Association to beekeeping projects of the FFA boys of the state; (4) The State Association began the publication of an official news letter which was appropriately named "The Bee Line." The object of this news letter was to "aid in the unification of the beekeeping industry in Kentucky" according to James E. Dierken of Louisville, who was its only editor; (5) The by-laws of the State Association's constitution were rewritten; (6) The State Beekeepers' Association adopted an official seal in April, which was designed by Mrs. Cora Burlingame, L. G. Pile, Fred O. Miller and James E. Dierken, all of the Louisville area. The seal was drawn by Charles Arnett, an artist of the Courier-Journal's Promotion Department. The colors were Emerald Green and Canary Yellow. This move was necessary for the body to become incorporated; however, the Association did not fully achieve this recognition until April 29, 1960.

1950 The Kentucky Department of Agriculture, in cooperation with the legislative committee of the Kentucky State Beekeepers' Association was successful in obtaining $300 from the Governor's Emergency Fund to initiate an apiary inspection service. This fund was allotted to train and organize men on a basis of 20 days at $15 per day. Chester Shepherd and Claude Rose, deputies on loan from the Indiana Apiary Inspection Service, were obtained to train the selected Kentucky men. The Kentucky Beekeepers' Association selected E. M. Miller, Eastwood, as State Apiarist; and Fred O. Miller, Louisville Assistant State Apiarist, with the following men to serve as deputy inspectors. They were: Morris Black, Defoe; J. D. Lane, Erlanger; L. G. Pile, Louisville; Otis K. Wolfe, Harlan; Elmo Wilson and James E. Dierken, Louisville. Upon the recommendation of the State Association these men were appointed by Commissioner of Agriculture, Judge Harry F. Walters, to initiate Kentucky's first apiary inspection inspection program, beginning in August, 1950. These beekeepers served the industry at great personal sacrifice, since no funds were available for salaries; they were paid $1.00 per year and 2c per mile for their services.

1952 1. Legislation provided $2,000 for yearly expenses incurred in promoting the Bee Law. However, no salary was paid for this part-time, on-request service to State Apiarist E. M. Miller of Eastwood, who served for eight years, beginning in 1949, to promote beekeepers' meetings, arrange educational exhibits and do inspection work throughout the state.

2. The Walter T. Kelley Company plant was moved from Paducah to Clarkson, the present location.

1954 1. Inspection service continued, however, it became necessary to reduce expenditures as an economy measure, with the appropriated funds being used for travel expenses only. The bee program was provided with $600-$700 additional funds for the promotion of the industry through the Division of Markets in a joint State-Federal Honey Marketing program.

2. Also, an amendment to the Bee Law provided for the raising of the registration fee as a means of providing income to apply toward the expenses incurred in the enforcement of the Law. Due to the lack of personnel necessary for the enforcement of this amendment, it has not proven to be an effective measure.

1955 1. Publication of "Kentucky 1955 Honey Production and Marketing Survey" by James M. Koepper and Mancil J. Vinson. This was a cooperative report of the USDA and the Kentucky Department of Agriculture.

2. Publication date of "How to Keep Bees and Sell Honey" by Walter T. Kelley of Clarkson. This practical beekeepers' book was revised in 1958.

3. The Kentucky Department of Agriculture, with E. M. Miller, Eastwood, Jefferson County, serving as State Apiarist, provided an educational display for beekeepers at the Farm and Home Week proceedings at the University. This was the first reference to beekeeping at these meetings that had ben made since the Association was moved to Louisville in 1944.

1956 1. Publication date of "Honey Plants Manual" by Dr. Harvey Lovell, University of Louisville, Department of Biology. Dr. Lovell also writes the popular monthly article "Let's Talk About Honey Plants" for GLEANINGS IN BEE CULTURE.

2. The Kentucky Department of Agriculture, the University of Kentucky and the State Beekeepers' Association combined efforts to again "revive" the beekeepers' meeting during Farm and Home Week, with thirty-three beekeepers and farm leaders attending.

1958 Tommy Hines, Morgantown, Butler County, was employed by the Kentucky Department of Agriculture as State Apiarist. This service was on a part-time, on-request basis, however.

1960 The State Assocition was successful in its fight which began in 1914 for full-time disease control. According to the Kentucky Department of Finance, "The Appropriation Act of the 1960 General Assembly includes funds for a full-time apiarist, a part-time apiarist, and necessary travel to provide inspection and educational services. The appropriation is $8,775 for each of the 1960-62 biennium, a total of $17,550." This program of service to Kentucky's beekeepers was placed under the supervision of Coburn Gayle, Entomologist for the Seate Department of Agriculture, with Tommy Hines of Morgantown serving as State Apiarist and William G. Eaton of Winchester as Assistant Apiarist. Thus begins the present-day era in Kentucky's beekeeping history.

Conclusion

It is evident from the preceeding chronological summary of events that several Kentucky beekeepers have carved an enduring name for themselves in the Beekeepers' Hall of Fame, simply because their inventive genius and quest for knowledge and progress enabled them to keep in step with the demands which the "new way" had suddenly placed upon them. In fact, these men of high stature and character in life, through a sense of complete devotion to duty, very often led the way as an entirely new industry was being developed.

May the fires which were kindled in the creative and productive minds of Kentucky's beekeepers never be snuffed out; may we resolve to kindle them afresh and anew every opportunity we have; and lastly, may the past serve us as a guide post for future events, rather than a hitching post.

Acknowledgements

In a study of this kind it is necessary to draw much from the writings of other persons and to solicit assistance from numerous organizations and individuals.

The writer expresses apprecition to Dr. Lee H. Townsend, Head, Department of Entomology and Botany, University of Kentucky, for general assistance in various ways and especially for help in arranging and editing the material.

Credit is due several agencies and individuals for assistance during the progress of the work and these are recognized as follows:

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Morris Black, Hillside Honey Farms, Defoe, Kentucky.

Kentucky Department of Agriculture, Frankfort, Kentucky.

Library, State Historical Society, Frankfort, Kentucky.

"The History of American Beekeeping," Frank C. Pellett, Collegiate Press, Inc., Ames, Iowa, 1938.

Friends and relatives of early Kentucky beekeepers.

Early beekeeping literature, Association records, personal effects, publications and correspondence.

AUTHOR'S NOTE—Addntional material has been received recently from the present Editor of *The American Bee Journal,* Vern Sisson, which reveals that a Kentucky Beekeepers' Association was organized in Lexington, Kentucky, on November 20, 1867.

A few facts contained in the interesting write-up of the event are as follows:

"Pursuant to notice previously given through the papers, quite a large number of beekeepers from various parts of the state met at the courthouse in this city, and on motion, R. T. Dillard, D.D., was called to the Chair, and J. W. Reynolds was appointed Secretary.

"Mr. D. Burbank, in a few pertinent remarks, stated the object of the meeting to be for the purpose of organizing an association of all interested in bee culture, and consulting as to the best means of encouraging and advancing this important interest."

According to the report, several members of the new group had kept honey bees for fifty years. Numerous discussions were given on the topics and developments occurring on that day.

The appointment of a committee to arrange business topics for consideration by the convention was made.

A four-member committee was appointed to draft a constitution; a committee was appointed to procure a speaker for the next meeting (second Tuesday of December, 11 a.m.); and various observations on management and production were made.

Whether this organization proved to be successful or not is not known at the present time, due to the lack of additional facts. It is believed, however, that the group continued to meet on an area basis, rather than as a state-wide association, and that they merged with other groups, which were organized later, to form the Kentucky State Beekeepers' Association in 1880, at a special called meeting in Louisville. The highlights of this event are described elsewhere in this paper.

COLD WAVE PATTERNS OF LEXINGTON, KENTUCKY AND ORLANDO, FLORIDA

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The unprecedented severity of the cold waves of the winter of 1962-63 has prompted this study of the cold wave patterns of Lexington, Kentucky and Orlando, Florida. During the 1962-1963 winter wave after wave of frigid polar air swept southward over the Eastern Cold Wave Track of North America bringing new minimum records to many stations, (Figs. 1, 5, 6). Newspapers headlined the damaging effects of these cold waves on such important and cold sensitive economies as the orange and vegetable industries of Florida.

This study of cold waves through the minimum temperature records of Lexington and Orlando has been undertaken as a pilot project in the appraisal of cold waves and accompanying minimum temperatures as weather and climate phenomena with unusual geographic effects. The major objective is an attempt to reveal distribution and frequency patterns of minimum temperatures as are associated with cold waves since in the United States all unusual minimum temperatures are associated with cold waves, (Figs. 1, 5, 6). A study of figures one and six suggests the definition of a cold wave as an invasion of cold air of 10 degrees F and lower or 20 degrees F below the mean minimum temperature. The 10 degrees F may moderate as the cold air moves southward but the 20 degrees below the normal mean minimum holds even in Florida.

In addition to this major objective, however, this study reveals that certain inferences are warranted relative to cold waves and that these inferences can be the topics for additional study. For instance banner newspaper reporting while true for the moment may exaggerate the damaging effects of the cold wave. In the Florida orange industry what was headlined as an almost total loss for the 1962-1963 crop due to the Dec. 11-14 cold wave turned out to be a relatively low percentage loss with an overall beneficial rather than detrimental effect on the orange industry. An AP press release from Lakeland, Florida of Dec. 14, 1962 reported that the cold Arctic air caused ice to form in from 75 to 100 per cent of the fruit regardless of smudge pots and windmills. The report explained that the damage was greater than in the 1957-58 cold wave when 30 million boxes of fruit were lost and 30,000 fruit trees killed. Harvest hands were reported to have abandoned the totally devastated vegetable farms and to have turned to save the iced oranges for juice. These reports were correct but the

30,000,00 boxes would not be a great percentage of the 163,000,000 box crop which Florida expected and the 30,000 trees would be a very minor percentage of the 600,000 acres of fruit orchards in Florida. Of course the vegetable crop was regrown in six weeks and the prices for citrus fruit had sharply increased. While in Florida, recovery and the resumption of a flourishing landscape obscures the damage of the cold wave and protective devices are the only evidence, elsewhere, the devastating aspect may prevail. In Kentucky the peach crop for the entire state for 1963 was a total loss and many orchards and trees entirely destroyed. North of Laredo Texas the entire citrus industry was destroyed in the cold wave of 1949 and is only now beginning to show recovery.

Geographically such a study as this may be useful in providing protection against widespread damage caused by the cold wave, especially south of the Ohio River where cold waves more frequently fall into the category of "Unusual Weather" and therefore inadequate provisions are made for them. A study of the Lexington cold wave pattern in Figure 1 shows that the cold wave of January 23-24, 1963 brought cold air 47 degree F colder than the normal minimum temperature of 26F. Failure to provide for this departure from normal weather resulted in the total destruction of the peach crop to mention only one item. Also a study of figure one reveals that the temperature fell to 20F below zero in 1899. A Study of Figure 6 shows that Kentucky is always exposed to the cold air masses of Canada where temperatures as low as 70 F below zero occur.

It is difficult to surmise what forethought would have saved Kentucky's peach crop. But afterthought reveals that the margin of protection may not be too wide. Figure 2, plates A, B, C, show that the tree kill of peach orchards was closely related to elevation and slope and that the crest orchards have survived. Estimates are that these crest orchards will produce close to a normal crop in Kentucky in 1964.

In Orlando, Florida care is taken to protect the valuable orchards against cold waves. Smudge pots elevate the radiating surface and heating devices and windmills are about as numerous as the fruit trees. With such protection this district has weathered the cold waves of the past, and a study of the minimum temperature patterns (Figs. 3, 4) of Orlando provides strong evidence that the future of this district is secure with the provisions now at hand. Table One and the graphs of Figs. 3 and 4 show that the Florida industry has weathered a tremendous amount of freezing weather since 1892. At no time, however, has the temperature fallen below 18 F in the Orlando district.

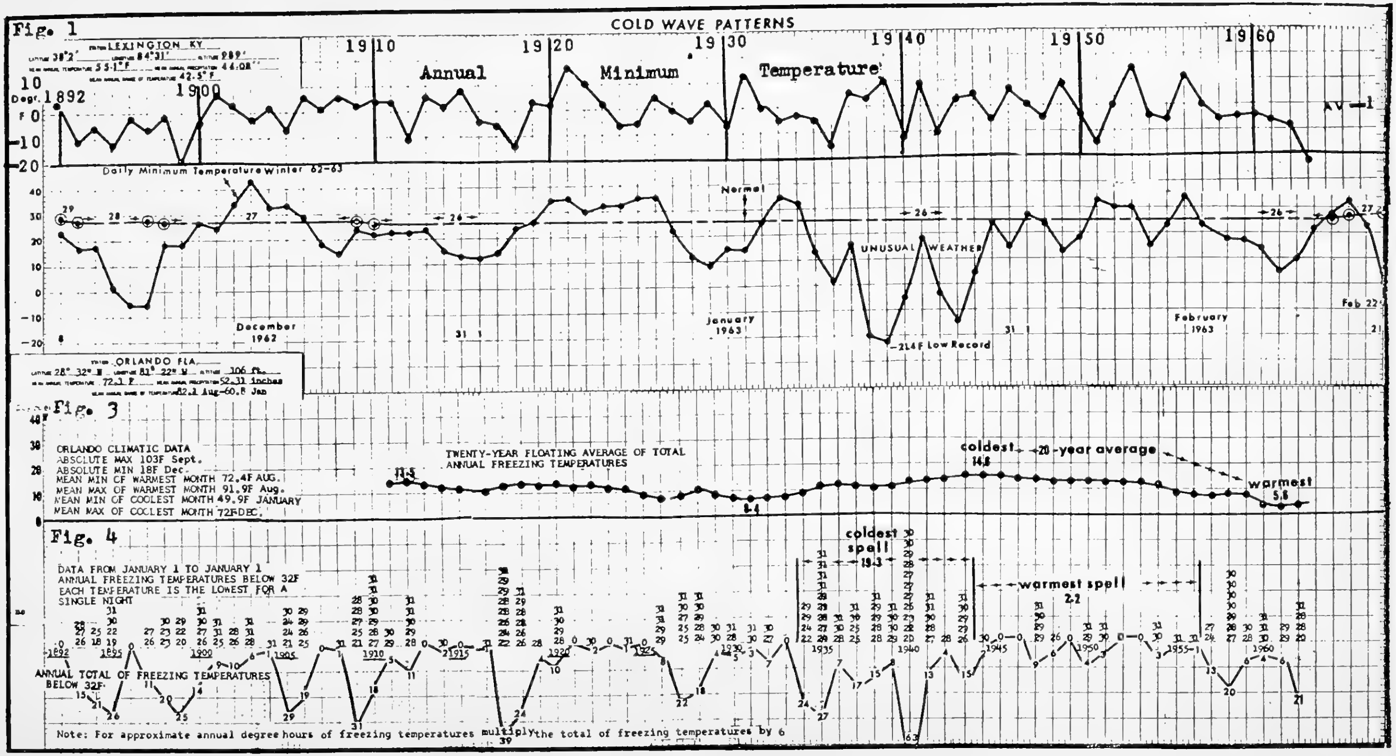

Fig. 1, 3, and 4. — Cold wave patterns of Lexington Kentucky, and Orlando, Florida.

Fig. 2.— Peach orchard damage in the Blue Grass caused by the cold wave of Jan. 23-24, 1963. The upper photograph was taken in an orchard which occupied a dip or trough. The middle photograph was taken in an orchard which occupied a slope from crest to trough. It is significant that the trees on the crest survived. The lower photograph is of a peach orchard which survived the cold wave. It did not bear in 1963—the summer following the cold wave, but it did bear in the summer of 1964.

Table 1. Cold Days at Orlando, Florida. Temperatures in Degrees Fahrenheit. Data from January 1 to January 1, 1892 to 1962.

Year	30F	25F	20F	18F	Year	30F	25F	20F	18F	Year	30F	25F	20F	18F
1892	0	0	0	0	1916	1	0	0	0	1940	8	2	1	0
1893	3	0	0	0	1917	6	2	0	0	1941	5	0	0	0
1894	0	1	0	1	1918	6	0	0	0	1942	1	0	0	0
1895	2	1	1	0	1919	1	0	0	0	1943	5	0	0	0
1896	0	0	0	0	1920	4	0	0	0	1944	1	0	0	0
1897	2	0	0	0	1921	0	0	0	0	1945	0	0	0	0
1898	1	2	0	0	1922	1	0	0	0	1946	0	0	0	0
1899	1	1	1	0	1923	0	0	0	0	1947	4	0	0	0
1900	4	0	0	0	1924	1	0	0	0	1948	1	0	0	0
1901	2	1	0	0	1925	0	0	0	0	1949	0	0	0	0
1902	2	0	0	0	1926	4	0	0	0	1950	2	0	0	0
1903	3	0	0	0	1927	3	2	0	0	1951	2	0	0	0
1904	1	0	0	0	1928	4	1	0	0	1952	0	0	0	0
1905	1	3	0	0	1929	2	0	0	0	1953	0	0	0	0
1906	3	1	0	0	1930	2	0	0	0	1954	2	0	0	0
1907	0	0	0	0	1931	2	0	0	0	1955	1	0	0	0
1908	1	0	0	0	1932	2	0	0	0	1956	1	0	0	0
1909	3	2	0	0	1933	0	0	0	0	1957	1	1	0	0
1910	7	0	0	0	1934	2	2	0	0	1958	7	0	0	0
1911	2	0	0	0	1935	8	1	0	0	1959	2	0	0	0
1912	5	0	0	0	1936	3	0	0	0	1960	3	0	0	0
1913	0	0	0	0	1937	2	2	0	0	1961	2	0	0	0
1914	1	0	0	0	1938	4	0	0	0	1962	3	0	1	0
1915	0	0	0	0	1939	4	0	0	0					

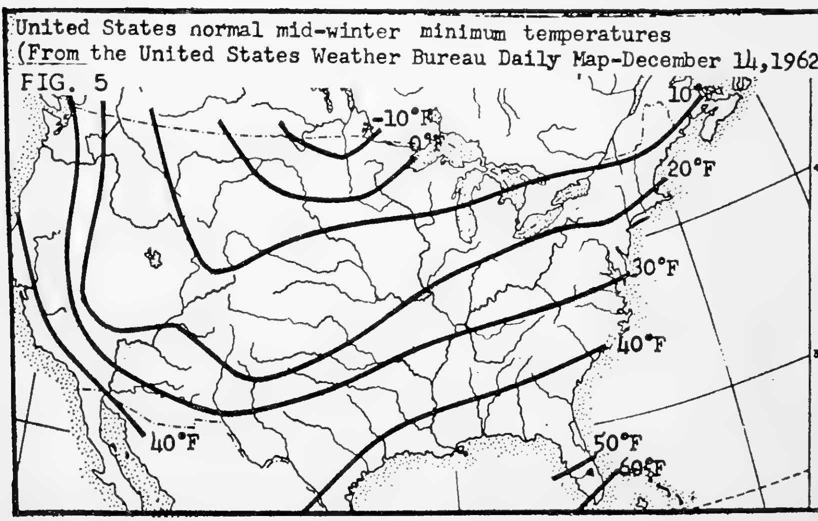

Fig. 5. — United States normal mid-winter minimum temperatures.

While the United States Weather Bureau keeps careful records of Track bending and pushing the normal minimal isotherms sharply southward along its main axis. The overall temperature gradient was reduced from the normal of 70 degrees F to 34 degrees F in minimum normal isothermal gradient and the actual recorded temperatures were sharply reduced along the entire track of the cold wave. For example Fargo, North Dakota showed a reduction from its normal minimum of zero degrees F to 14 degrees F below zero, Chicago, Ill from 18

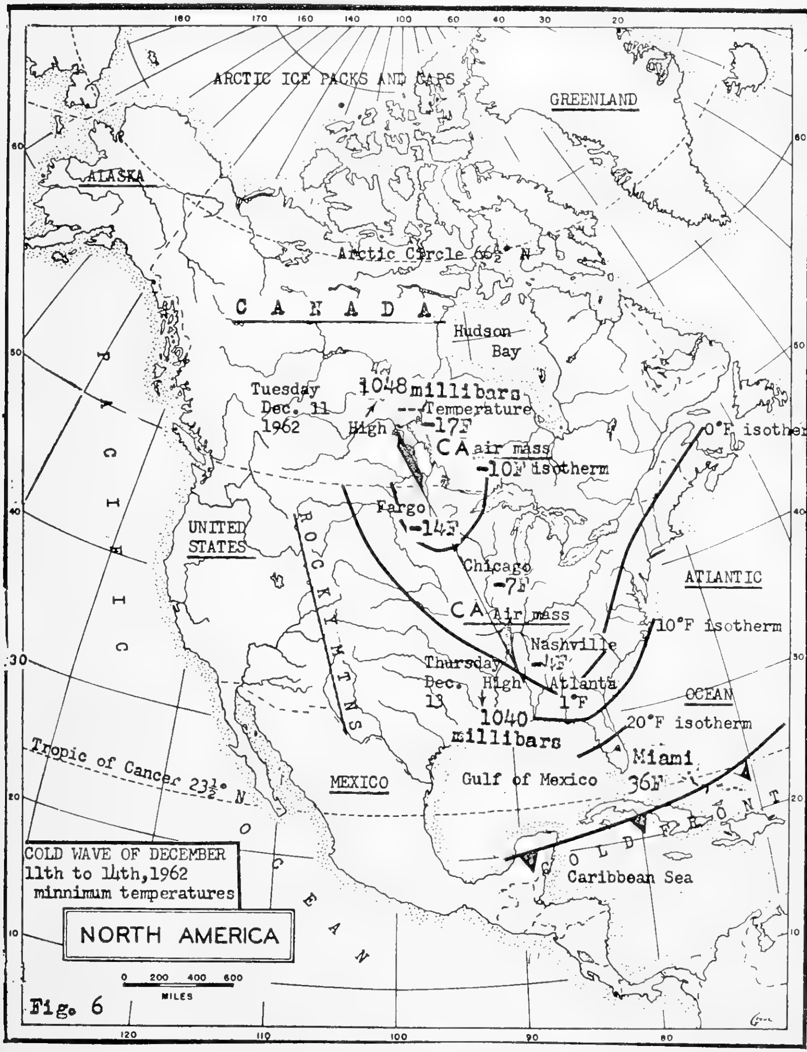

Fig. 6.—Cold wave of December 11 to 14, 1962. Minimum temperatures.

such "Unusual Weather" as the cold wave, much can be done to signalize these data into meaningful maps and charts and to instruct the public as to their significance. For example the United States Weather Bureau map of normal mid-winter minimum temperatures (Fig. 5) shows the roughly parallel isotherms crossing the United States beginning with –10 degrees F in the north central United States and terminating at the tip of Florida with a plus 60 degrees F showing a relatively steep gradient in *minimum* winter temperatures of 70 degrees F for a distance of about 1,800 miles and about 4 degrees F per hundred miles.

Against this background of normal mid-winter minimum temperatures a composite map from three daily weather maps of the December 11-14 cold wave was arranged and is quite revealing of the elements and operation of a cold wave, (Fig. 6). A Continental Arctic (cA) air mass appears in Canada conditioned to –17 degrees F with a density of 1048 millibars. Within three days this cA air mass has poured southward along the Eastern North American Cold Wave Track bending and pushing the normal minimal isothers sharply southward along its main axis. The overall temperature gradient was reduced from the normal of 70 degrees F to 34 degrees F in minimum normal isothermal gradient and the actual recorded temperatures were sharply reduced along the entire track of the cold wave. For example Fargo, North Dakota showed a reduction from its normal minimum of zero degrees F to 14 degrees F below zero, Chicago, Ill. from 18 degrees F to minus (–7) degrees F, Nashville, Tennessee from 40 degrees F to –4 degrees F, Atlanta, Georgia from 45 degrees F to 1 degree F, and central Florida from 50 degrees F to 20 degrees F. . The destructive capacity of the cold wave is due to (1) its abruptness, at any one place a matter of a few hours and for the entire United States two to three days, (2) its wide departure from normal, especially in the South in this instance as much as 44 degrees F, (3) its areal coverage with devastation more widespread than for any other natural calamity (4) the fact that it strikes the most highly cultured area in the world in economic development. It is fortunate that the cold wave is of such short duration with its most severe temperatures often passing in a single night. This promotes unusual protective devices. Also the economy of an area will have adjusted to a usual degree of tolerance in the departure of cold temperatures from the average.

For instance the daily minimum temperatures at Lexington for the winter of 1962-'63 discloses the above principles when plotted in a line chart, (Fig. 1). The daily normal minimum temperature for the winter months is 26 degrees F. The departure from this normal is not great usually above zero F and the average lowest annual temperature is –1 degree F. . On nine occasions in seventy years the temperature fell to –10 degrees F and in two of these instances 1899 and January of 1963 the extremes of twenty below zero were reached. Great damage was inflicted in this last cold wave at Lexington due to the progress in the economy and the absence of preparation for it. Plumbing, even in new homes, burst from freezing, plant nursuries suffered severe winter kill in their field stock and the entire peach crop was dstroyed. There is no room for detailed analysis in this article but the statement appears warranted that forethought and simple devices would have prevented most if not all of the damage from the last cold wave.

But at Orlando, Florida, where the sensitive orchards are vulnerable to temperatures from 32 degrees F downward, simple provisions have not sufficed and elaborate and expensive protective devices had to be installed. Also the need for such equipment is evident when the record for the past 70 years at Orlando shows that only 14 of these 70 years were frost free (Fig. 4). During the "Cold Spell of 1934-1944 not a single winter was frost free. The coldest winter of 1939-1940 had 11 nights with frost or below 32 degrees F. On the coldest night of 1940 the temperature fell to 20 degrees F and the protective devices had to overcome at least 72 degree hours of freezing weather. That such elaborate cold protecting devices and conserving equipment had been installed in the Florida orchards proves what astonishing adjustments thoughtful men can and will make when and where necessary and desirable.

The periodicity shown by the graphs of minimum temepratures for Orlando (Figs. 3, 4) raise many questions beyond the scope of this paper but two features deserve remarks. First, figure 3, the floating minimum temperature average, shows fluctation in the freezing temperature totals but no definite trend either toward warmer or colder weather can be positively stated. At present there appears a warming trend since 1944 but to argue that this trend will continue would be to predict startling changes in the not distant future. It appears much safer to assert that a cooling trend will set in but with no more serious effects than in the past. Second, in figure 4, there is evidence that "cold spells" and "warm spells do alternate and follow each other. Since there appears no regularity in this fluctuation any prediction would be questionable excepting to say that judging from the past the Florida fruit districts are prepared for the worst in cold waves.

Notes and References:

The author composed and prepared all illustrations used. Data was obtained from the United States Weather Bureau and from the United States Department of Agriculture.

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FIRST RECORD FOR THE GREEN ALGAE, CHAETOMORPHA NODOSA KUTZING IN UNITED STATES WATERS

PETER A. ISAACSON*

Marine Resources Operation, California Department of Fish and Game

In July of 1962 a single specimen of *Chaetomorpha nodosa* was collected by a field party headed by Dr. Harold J. Humm of the Duke University's Botany Department, near the Radio Island Breakwater at Beaufort, North Carolina.

Measurements taken from the specimen after preservation in a five percent solution of formalin sea water showed the cells to vary in diameter from 75 to 100 Mu. The basal cell is clearly attached and the proximal cells are some what elongated (Fig. 1). These measurements compare favorably with those found in the species description in Marine Algae of the Eastern Tropical and Subtropical Coasts of America (Taylor 1960).

Previous records of *C. nodosa* have been from French Guiania as reported by Taylor (loc. cit.). This new record represents an extention of the known range by approximately 2,600 miles and is therefore of particular interest with regards to its distribution in the Western North Atlantic.

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* Present Address: State University of New York, Stony Brook, New York.

Fig. 1.— Photomicrograph of *Chaetomorpha Nodosa* specimen.

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A STUDY OF HYDROGEN BONDING IN ALCOHOL-DIOXANE SYSTEMS BY INFRARED SPECTROSCOPY

PART II—PRIMARY NORMAL ALCOHOLS

JOHN H. WALKUP, LARRY DAVIS, and GARY MARQUARDT*
Centre College of Kentucky

In a previous paper (Walkup, Lyford, Marquardt, and Robinson, 1964) the effects of the structure of several substituted aliphatic alcohols on the frequency shift in alcohol-dioxane systems were reported. The absorption frequency of the monomer or free OH stretch of the alcohol which occurs in the 3610-3640 cm^{-1} region was shifted to the 3500 cm–[1] region on formation of a hydrogen-bond complex with p-dioxane. When the concentrations of the alcohol and p-dioxane were kept low, an equilibrium existed between the OH monomer form and the O . . . H . . .: X hydrogen-bonded form of the alcohol (Becker, 1961) where :X is the electron donor, p-dioxane. The extent of the frequency shift ($\Delta\gamma_1$) was found to be dependent on the structure of the alcohol and on several other factors (Pimentel and McClellan, 1960).

In this paper, the results of a study of the hydrogen bonding between the primary normal alcohols ($C_1 - C_{16}$) and p-dioxane in carbon terachloride are reported. It is hoped that some conclusions about the effect of the structure of the alcohol on the frequency shift ($\Delta\gamma_1$) can be drawn.

The primary normal alcohols which were studied in dilute solutions of p-dioxane in carbon tetrachloride were: methanol through n-dodecanol, n-tetradecanol, and n-hexadecanol. The alcohols were grouped so as to study the effect of lengthening the carbon chain.

Experimental

Spectra were obtained on a double-beam Perkin-Elmer model 337 grating infrared spectrometer equipped with an ordinate scale readout and used with a Sargent model SRL recorder. Using the expanded ordinate and abscissa scales the frequency accuracy was estimated at $\pm$ 2 cm^{-1} over the 4000 cm^{-1} to 3000 cm^{-1} region where the spectra were taken. Reproducibility was found to be excellent.

The spectrometer used was linear in wave number, and the polystyrene absorption peaks at 4082.6 cm^{-1} and 3002.8 cm^{-1} (Nakaniski,

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* Present Address—Gary Marquardt, Medical School, University of Kentucky.

1962) and at 2850.7 cm^{-1}, 1601.4 cm^{-1}, 1583.1 cm^{-1} and 1494.0 cm^{-1} (Perkin-Elmer, 1964) were used to calibrate the recorder chart paper. The absorption frequency of the free OH and hydrogen-bonded peaks of the alcohol-dioxane system were obtained by using the 3002.8 cm^{-1} absorption peak of polystyrene film as a standard with each spectra.

The room was air-conditioned and held fairly constant at 22° ± 1°C. The slit width was held constant at normal program. The sample cells had Irtran 2 windows and were matched to a cell thickness of 1.0 mm in all cases.

The alcohols used were obtained from the Polyscience Corporation in kits. The purity of the alcohols was at least 97%. The p-dioxane and carbon tetrachloride were reagent grade meeting A.C.S. purity specifications. The concentration of the alcohol in each case was approximately 0.020 M to 0.30 M, and the concentration of the p-dioxane was approximately 0.50 M. Several spectra for each alcohol-dioxane system were taken, and an average of the absorption frequencies was obtained. All alcohol-dioxane systems were run at least two different times, and in some cases, new solutions were made up to check reproducibility.

Discussion of Results

The absorption frequencies for the monomer OH stretch and the hydrogen-bonded complex and the shift ($\Delta\gamma_1$) between them are listed in Table 1. Literature values for the monomer OH stretching frequencies of some of the alcohols are also given (Barrow, 1955; Kuhn, 1952).

Table 1

Alcohol with p-dioxane	Free OH in cm^{-1}	H-bond Complex in cm^{-1}	Shift $\Delta\gamma_1$	Free OH in cm^{-1}	References
Methyl	3643	3517	126	3642	Kuhn
Ethyl	3634	3511	123	3634	Barrow
n-Propyl	3636	3511	125	....	....
n-Butyl	3637	3510	127	3636	Barrow
n-Amyl	3639	3513	126	....	....
n-Hexyl	3637	3511	126	....	....
n-Heptyl	3636	3510	126	....	....
n-Octyl	3636	3510	126	....	....
n-Nonyl	3636	3510	126	....	....
n-Decyl	3636	3510	126	....	....
n-Undecyl	3636	3510	126	....	....
n-Dodecyl	3636	3510	126	....	....
n-Tetradecyl	3636	3510	126	....	....
n-Hexadecyl	3636	3510	126	....	....

As shown by Fig. 1, the shift ($\Delta\gamma_1$) is seen to decrease when a methyl group is added to the carbinol carbon and then increase when the carbon chain is lengthened up to n-Butanol:

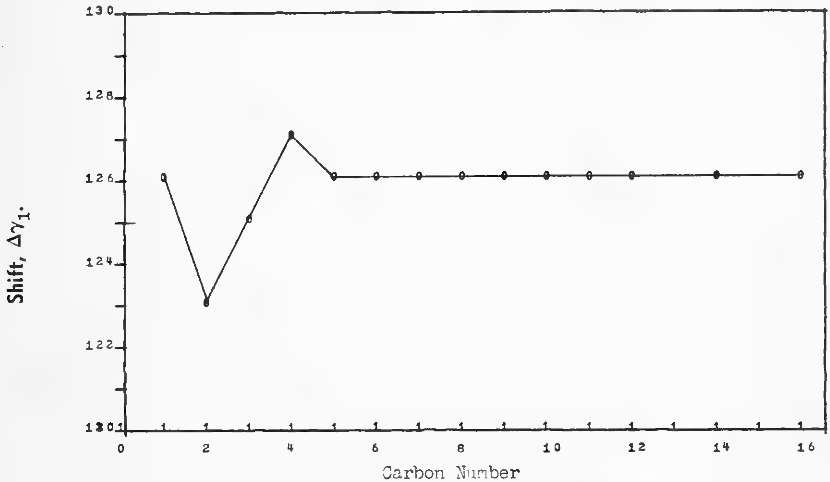

Fig. 1.— Primary normal alcohols vs. frequency shift ($\Delta\gamma_1$).

The shift ($\Delta\gamma_1$) is then decreased slightly and remains the same for the higher normal alcohols ($C_5 - C_{16}$). The decrease in shift that occurs when a methyl group is substituted on the carbinol carbon of the alcohol is substantiated by Becker (1961) and by previous studies (Walkup, Lyford, Marquardt and Robinson, 1964). As the carbon chain is lengthened, the electron-pushing effect of the methyl group is reduced and an increase in shift ($\Delta\gamma_1$) is observed for n-Propyl and n-Butyl alcohol. As the carbon chain is lengthened beyond n-Butyl alcohol the electron-pushing effect of the methyl group is further reduced. However, the steric hindrence of the lengthened carbon chain brings about a slight reduction in shift ($\Delta\gamma_1$) beyond n-Butyl alcohol. Since the steric hindrence is approximately the same for all the higher normal alcohols and the electron-pushing effect of the methyl group is negligible there is no change in the frequency shift ($\Delta\gamma_1$) past n-Amyl alcohol.

A comparison of Fig. 2 with Fig. 1 shows an interesting relationship between the absorption frequency of the free OH stretch and the frequency shift ($\Delta\gamma_1$) for the alcohol-dioxane systems studied.

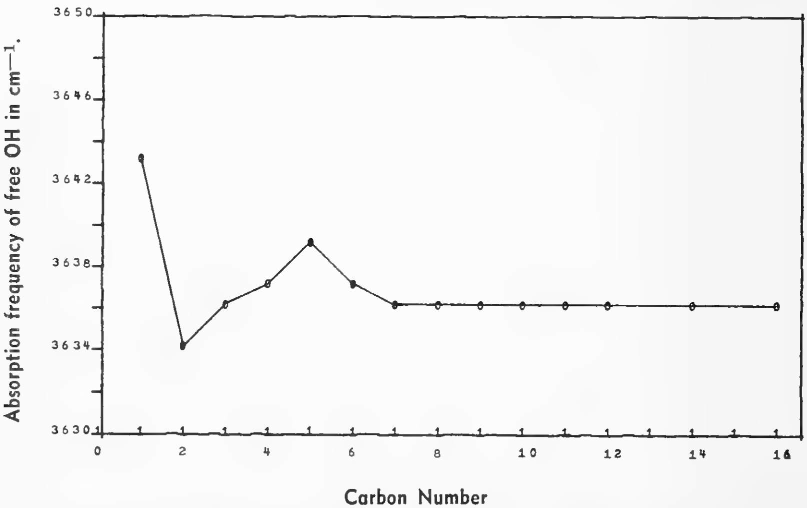

Fig. 2.— Primary normal alcohols vs. absorption frequency of free OH.

In general, the shift ($\Delta\gamma_1$) increases as the frequency of the monomer OH stretch increases. This relationship cannot be explained from the limited data available, but it is probably due to the characteristics of the solvents carbon tetrachloride and p-dioxane. Although some work has already been done in this field (Allerhand and Schleyer, 1963) more work is needed concerning the effects of solvents on the frequency shift in alcohol-base systems.

Summary

The absorption frequency of the monomer OH stretch and the hydrogen-bonded complex are given for fourteen primary normal alcohols in dilute solution with p-dioxane, a strong proton acceptor. An attempt is made to relate the extent of the frequency shift ($\Delta\gamma_1$) between the free or monomer OH and the hydrogen-bonded complex to th length of the carbon chain.

Acknowledgments

This work was made possible by a grant from the Petroleum Research Fund of the American Chemical Society. The infrared spectrometer used in this study was obtained by a matching grant from the National Science Foundation. The authors wish to express their appreciation to the PRF and the NSF for the grants and to Dr. Harold N. Hanson for his helpful suggestions.

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A STUDY OF A CLIFTY CREEK ROCK SHELTER

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Introduction

This site is in the Hadley Community, which is located in the northwestern part of Warren County. It is in the Big Clifty sandstone formation, about one half mile down Clifty Creek from the point where U.S. Highway 231 crosses the stream. The county road that begins at Rolling Springs Church and connects with Highway 231 runs under the outer part of this shelter, and no doubt much material pertinent to this study was lost when it was built.

In all probability the earliest settlers of this region observed that this formation had been occupied by primitive man, and it is known that for many years this has been a favorite spot for the activities of amateur collectors of Indian relics. I became interested in this project when Dr. Arch Cole, Dr. Edmund K. Hall, and I made a preliminary collection of materials, and decided it was worth further study. Unfortunately, both of these fine gentlemen passed away before much had been done on the investigation.

The nature of the shelter is such that the materials that were left in it were well preserved. It is quite dry, and it appears that it has been that way for a long time. The floor is covered about six inches deep with a loose layer of sandy dust, that is upon a hard layer of clay-like material. The layer of dusty material extended back into an area where the ceiling was so low that the previous collectors avoided this part of the shelter, and it was left undisturbed. There is evidence that the activities of packrats contributed greatly to the preservation of the bone material in this collection, because most of it was found in the region where the ceiling was only a few inches above the floor or in contact with it. The bones are broken in short pieces, but they are otherwise in fine condition, except for some damage that was done by gnawing animals.

Collecting Method

The artifacts were collected by shoveling the loose top layer of the floor through a large sieve, made of a wood frame that held 5/16 mesh hardware cloth. The hard base layer was not disturbed except for a few sampling operations, because no artifacts were found in this stratum. A shovel with a flat bottom and a long handle, was

Fig. 1.—Map of the Rock House area.

used, and this tool made it possible to collect the materials in the low part of the shelter.

Bones

The bone material was the most spectacular part of the collection. Approximately a bushel of bones was collected, and most of them were broken into lengths varying from two to three inches to eight or ten inches. A large percentage of the pieces were about six inches long. Bones that weer naturally not longer than six to eight inches were not broken. Apparently, if the meat were cooked, it was done by boiling it in kettles, because there is no evidence of scorching or browning of the bones, which would be expected if the meat had been roasted or broiled. The bones were broken into lengths suitable for cooking in medium sized pots, and since there were potsherds present, it appears that the meat was stewed. There was a complete deer metatarsal (cannon bone) that had been made into a tool, presumably to dress hides, during the tanning process. Human bones were almost completely absent from the collection. Only a molar and a few small bones were found.

Families and Species of Animals

There are twelve families and thirteen species of animals represented in this collection, as listed below:

Emydidae
 Terrapene carolina—Box Turtle (6)*

Meleagridae
 Meleagris gallopavo—Turkey (6)

Didelphidae
 Didelphis marsupialis—Opossum (10)

Leporidae
 Sylvilagus sp.—Rabbit (6)

Sciuridae
 Sciuris sp.—Squirrel (1)
 Marmota monax—Woodchuck (1)

Cricetidae
 Neotoma floridana—Wood Rat (1)

Canidae
 Urocyon cinereoargenteus—Gray Fox (1)

Ursidae
 Ursus americanus—Black Bear (45)

Procyonidae
 Procyon lotor—Raccoon (1)

Mustelidae
 Mephitis mephitis—Striped Skunk (2)

Felidae
 Mephitis mephitis—Striped Skunk (2)

Felidae
 Felis concolor—Mountain Lion (2)

Cervidae
 Odocoileus virginianus—White-tailed Deer (190)
 Cervus canadensis—Elk (2)

---

* Number of specimens.

About half of the species represented in the bone collection are now fairly common in the area of the rock shelter, and it is impossible to determine which of these bones are from the kitchen refuse of primitive man, or which are from a later inclusion. However, since they were intermingled with the others, it seems logical to assume that many of them were from animals eaten by primitive man.

Stone Artifacts

The amount of this material collected was small, which was not surprising, since artifacts of this type were the objectives of the numerous collectors, who had previously searched this location. There are a few rough stone scrapers and seven complete, or almost complete projectile points. There are two small and three larger triangular points which are associated with the Woodland or Mississippian cultures. Two of them are lanceolate with a neck and are not classified. They probably belong to the Archaic Period.

Potsherds

About twenty pieces of broken pottery were found, representing four known types:

O'Neal Plain (1)*	Bell Plain (3)
Mulberry Creek Plain (6)	Neeley's Ferry Plain (9)

There is also a limestone and shell tempered piece which was not classified.

Comments and Conclusions

It is evident that the Whitetail deer was a staple food animal of primitive man at this rock shelter, for more than half of the identifiable bones were of that species. The next most common animal represented in this collection was the Black Bear. The bones of this animal constitute about one fourth of the total collection. Less than one fourth are from the other eleven species. However, this may be misleading, for it seems reasonable to assume that the bones from the smaller animals would be more likely to be destroyed, which would account for the absence of the bones of other desirable food forms, such as the muskrat. The author does not state emphatically that all of the species that are listed were used for food, but that they probably were so used. It is not difficult to imagine conditions when any species that is listed would not be avidly eaten.

* Number of potsherds.

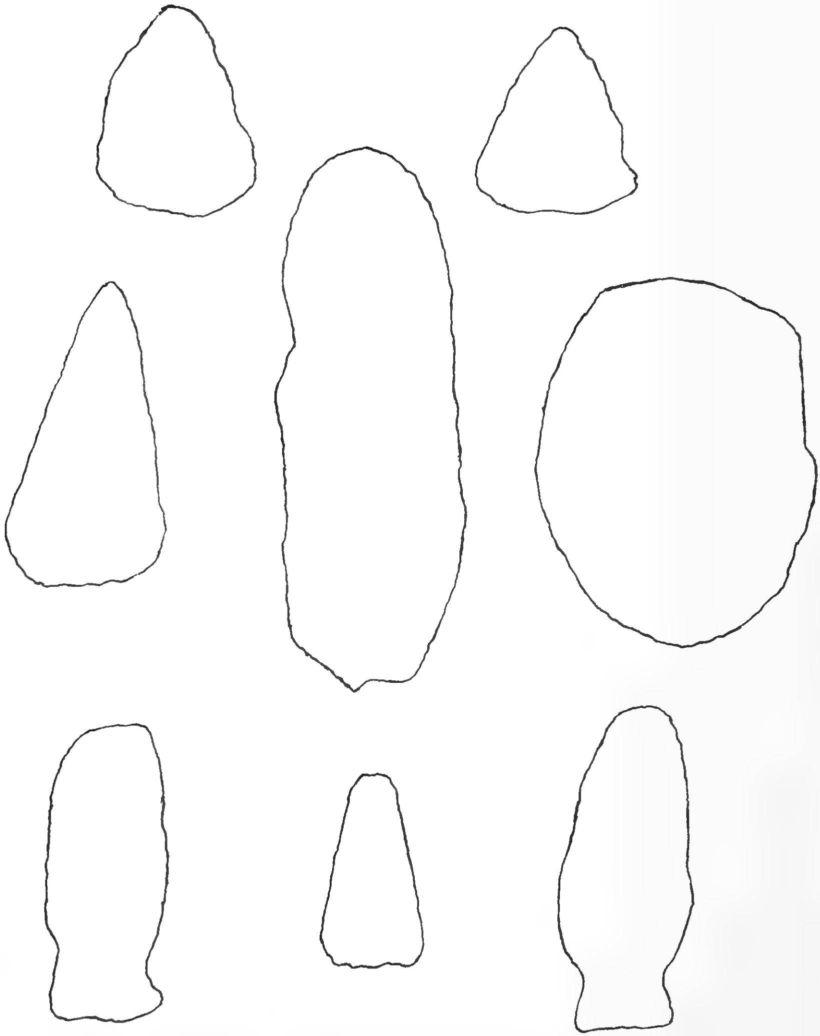

Fig. 2.— Tracings of the types of flint artifacts found in the Rock House.

The proportion of deer bones in this shelter is similar to the results of investigations at the rock shelter at Modoc, in southern Illinois. (1) The bones of Black Bear were also common at this place and at Russell Cave in northern Alabama. (1)

The absence of Bison bones at this site and also at the rock shelters in Illinois and Alabama, seems at first to be quite odd, but according to Dr. John E. Guilday of Carnegie Museum, these animals were absent from southeast U.S. until early Colonial times, at which time they crossed the Mississippi River from the west, and spread into this area. The bones of Mastodon and Mammoth weer absent. They probably had become extince long before the beginning of the Woodland and Mississippian cultural periods.

The types of pottery and flint artifacts found at this site both indicate that it was occupied by primitive man during the Woodland and Mississippian cultural periods. The presence of archaic men at this place is inconclusive.

Acknowledgments

I owe a deep debt of gratitude to Dr. John E. Guilday, Associate Curator, Section of Mammals, Carnegie Museum, for identifying the bones, and also for other assistance. I thank the members of the Department of Anthropology, University of Kentucky, for their assistance in classifying the pottery.

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RADIOLYSIS OF 1,5,9-CYCLODODECATRIENE

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The present study of the Co-60 gamma ray radiolysis of cyclododecatriene was undertaken to compare its radiation stability with that of other cyclic hydrocarbons which differ in ring size and degree and arrangement of unsaturation.

Experimental

The irradiations were carried out at an intensity of approximately 2.0×10^5 rad/hr. A total of twenty-six samples were irradiated with total doses ranging from 4.75 to 157.5×10^6 rad. The ferrous sulphate dosimeter was used to calculate intensities. The radiation source was similar to that described previously (Burton, et al., 1955). The cis-trans-trans isomer of 1,5,9-cyclododecatriene used in this study was obtained from the Cities Service Company. Samples were pipetted into clean, Pyrex, break-seal tubes, degassed on a high vacuum system by alternate freeze-thaw cycles, and sealed under vacuum. Irradiations were carried out at approximately 18°C.

Analysis of the irradiated products was carried out as soon as possible after irradiation. Gases were collected and measured with a Toepler pump. Separations were made of gases which were non-condensable at –198°C. (liquid nitrogen), –120°C. (ethyl bromide mush) and –78°C. (acetone-dry ice). These were considered to be hydrogen, ethylene, acetylene, and a C_3 fraction identified by gas chromatography as a mixture of propene and propane. The Toepler pump was so designed that after measurement of the gas volume, the gas could be directly injected into the carrier gas stream of the vapor phase chromatograph. The total measured volume of gaseous products was injected into the carrier gas stream at one time. Analyses of products were made by standard gas chromatography with a four foot column of silica gel at 27°C. Nitrogen was used as a carrier gas in the hydrogen determinations and helium was used for all others. The products were identified by retention times based on comparisons with similar mixtures of known compounds. Similar results were obtained with a dimethylsulfolane on diaomaceous earth column packing (Perkin Elmer Vapor Fractometer). The results are given in Table I as the average values for 14 different samples irradiated for total doses of 4.75 to 157.5×10^6 rad. Over this dose range there is no dose dependence for the G values. The non-gaseous products were not analyzed. Analysis with a column consisting of three inches of activated charcoal followed by three feet nine inches of silica gel with helium gas a carrier was used in an unsuccessful attempt to detect methane in the product gases.

Table I
Average G-Values of the Products of the Radiolysis of Cyclododecatriene

Product	G-Value	Retention Time Observed[a]	Retention Time Reported[b]
Acetylene	0.006 ± 0.0005	2.48	2.43
Ethylene	0.005 ± 0.0007	0.30	0.32
Propane[c]	0.0004 ± 0.0008	0.70	0.65
Propene		1.18	1.14
Hydrogen	0.437 ± 0.010		

a Dimethylsulfolane on diatomaceous earth, helium, 32 cc./min., 38°, time in min. from air peak.

b (Scholly and Brenner, 1961).

c Includes less than 5% propene.

Results and Discussion

The data on the G-values for the gaseous radiolysis products from cyclododecatriene establish that the principal product is hydrogen (G = 0.437) and that gaseous ring cleavage products are formed in smaller amounts (G = 0.015). The G(H_2) value is intermediate between values of 5.37 for cyclohexane and 1.2 for cyclohexene (Freeman, 1960) and values of 0.04 for benzene (Gordon and Burton, 1952) and 0.02 for cycloöctatetraene (Shida, et al., 1958). The G (cleavage products) of 0.015 is of the same order as values for benzene (0.020) and cycloöctatetraene (0.018), and cyclohexene (0.015).

There are two factors usually considered in accounting for the increased radiation stabilities of aromatic and alicyclic unsaturated hydrocarbons. These are resonance stabilization of aromatic compounds such as benzene and cage effects operative with the alicyclich types such as cycloöctatetraene (Franck and Rabinowitch, 1934). The absence of a planer structure in cyclododecatriene precludes resonance stabilization. It is, therefore, concluded that the low G(H_2) value for this compound, as with other unsaturated alicyclic types, is to be attributed to cage effects. The presence of allylic hydrogen atoms accounts for the somewhat larger G(H_2) as compared to that of cycloöctatetraene which has no such allylic hydrogen atoms.

The ring fragmentation products are somewhat unusual. The absence of butadiene, which was carefully checked, is noteworthy because cyclododecatriene can be considered to be a trimer thereof. The products formed require decomposition and fragmentation patterns which are not yet completely understood. As with other cyclic hydrocarbons irradiated in the liquid state, only a limited variety of cleavage products are formed. All of the products identified have been observed as radiolysis products of other acyclic hydrocarbons.

Acknowledgment: This research was supported in part under Contract AT-(40-1)-2055 between the Atomic Energy Commission and the University of Louisville. The authors are grateful for this assistance.

Summary

Cobalt-60 gamma irradiation induced decomposition of liquid cis-trans-trans 1,5,9-cyclododecatriene at 2×10^5 rad/hr. and total doses of 4.75 to 157.5×10^6 rad gives hydrogen ($G = 0.437$), acetylene ($G = 0.006$), ethylene ($G = 0.005$), and propane/propene ($G = 0.0004$). These $G(H_2)$ values are intermediate between those for cyclohexene ($G = 1.2$), benzene ($G = 0.04$), and cyclooctatetraene ($G = 0.02$) and the yield of cleavage products is of the same magnitude as for benzene and cyclooctatetraene. These low values indicate a stability attributable to cage effects.

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DETECTING ANIMALS TAGGED WITH Co^{60} THROUGH AIR, SOIL, WATER, WOOD, AND STONE

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Since radioactive tagging of animals to trace position and movements is being so widely used in ecological work with various vertebrate animals (Griffin, 1952; Godfrey, 1953, 1954a, 1954b, 1955; Jenkins, 1954; Pendleton, 1956; Karlstrom, 1957; Punt and van Nieuwenhoven, 1957; Miller, 1957; Kaye, 1960, 1961; Gifford and Griffin, 1960; Johanningsmeier and Goodnight, 1962; Barbour, 1963; Harvey and Barbour, 1965), it is desirable to obtain data on the effectiveness of the radioactive source for locating tagged animals. The purpose of this study was to measure the range at which a tag of approximately 45 microcuries of Co^{60} could be detected with a portable radiation detector through air or when the tag was located at various depths beneath soil, water, wood, or stone.

Tags used were 45 microcuries of Co^{60} alloy wire 0.7mm in diameter and 2.5 mm long, which have been found adequate for marking voles, *Microtus ochrogaster,* (Barbour, 1963; Harvey and Barbour, 1965) and moles, *Scalopus aquaticus,* (Harvey and Barbour, in m.s.).

Detection apparatus consisted of a Victoreen model 489 Thyac II transistorized portable survey meter equipped with scintillation probe, earphones, and shoulder strap.

To determine range of detection through air, the probe was placed successively at 0.5 ft. intervals from a tag, and readings in counts per minute were taken at each distance. This procedure was repeated until a distance was reached that gave a reading of less than twice the normal background radiation (background was usually 600-1000 counts per minute, depending on the particular survey meter used). Two times background was considered the minimum count necessary to detect a tag.

Range of detection through soil, water, wood, and stone was measured by placing a tag beneath 0.5 ft. of the material and then taking readings at 0.5, 1, 2, 3 ft., etc., from the surface of the material until a reading of less than two times background was obtained. The tag was then placed successively under 1, 1.5, 2 ft., etc., of the material and the procedure repeated.

Results are given in Tables 1, 2, 3, 4, and 5.

Because of variations in the amount of normal background radiation and differences in the sensitivity of survey meters used, the results presented in Tables 1-5 are not precise. Readings through other types of stone, soil, etc. would no doubt give somewhat different results. However, it is believed that this study gives a useful estimate of the range of detection through these substances which will aid in determining tag strengths needed for future studies.

Table 1.— Range of detection through air of a 45-microcurie Co^{60} tag. All readings are expressed as approximate times normal background radiation.

Distance Through Air (ft.)	Approximate Times Background
0.5	53.3+
1.0	34.7
1.5	25.0
2.0	20.3
2.5	17.4
3.0	11.9
3.5	9.5
4.0	6.9
4.5	5.9
5.0	4.6
5.5	4.0
6.0	3.2
6.5	2.7
7.0	2.3
7.5	2.0
8.0	<2

Table 2.— Range of detection through soil of a 45-microcurie Co^{60} tag. All readings are expressed as approximate times normal background radiation.

Distance Through Soil (ft.)	Distance Through Air (ft.)							
	0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0
0.5	31.3	16.6	10.0	4.3	3.1	2.6	2.2	<2
1.0	11.3	8.7	3.5	2.6	2.1	<2	<2	
1.5	2.7	2.2	<2	<2	<2			
2.0	2.2	<2						
2.5	<2							

Table 3.— Range of detection through water of a 45-microcurie Co^{60} tag. All readings are expressed as approximate times normal background radiation.

Distance Through Water (ft.)	Distance Through Air (ft.) 0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0
0.5	29.0	21.0	13.0	6.5	4.0	3.0	2.0	<2
1.0	15.3	7.7	4.0	2.9	2.6	2.2	<2	
1.5	7.8	5.0	3.4	2.5	2.2	<2		
2.0	3.7	2.8	2.2	<2	<2			
2.5	2.1	<2	<2					
3.0	<2							

Table 4.— Range of detection through wood of a 45-microcurie Co^{60} tag. All readings are expressed as approximate times normal background radiation.

Distance Through Wood (ft.) (1/2 pine, 1/2 oak)	Distance Through Air (ft.) 0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0
0.5	31.0	21.3	12.2	6.1	3.6	2.9	2.3	<2
1.0	18.0	11.3	8.1	3.5	2.7	2.1	<2	
1.5	9.3	5.3	3.4	2.5	2.0	<2		
2.0	4.3	3.3	2.3	<2	<2			
2.5	3.1	2.4	<2					
3.0	2.1	2.0						
3.5	<2	<2						

Table 5.— Range of detection through stone of a 45-microcurie Co^{60} tag. All readings are expressed as approximate times normal background radiation.

Distance Through Stone (ft.) (Solid Limestone)	Distance Through Air (ft.) 0.5	1.0	2.0	3.0	4.0	5.0
0.5	16.6	8.7	4.0	3.0	2.0	<2
1.0	4.3	3.1	2.1	<2	<2	
1.5	<2	<2	<2			

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A CASE OF DICHOCEPHALY IN LAMPROPELTIS DOLIATA TRIANGULUM

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As a result of an article on dichocephaly in *Natrix s. sipedon* (Ernst, 1960, Bull. Phila. Herp. Soc. 8(5):17), I learned that there was a snake with the same anomaly in the collection of Columbia High School, Columbia, Pennsylvania. Upon investigating, I found the snake to be a juvenile female *Lampropeltis d. triangulum.*

I could find no information on the capture of the snake with the exception that it had been at the high school since before 1945. The snake is preserved in formaldehyde, despite this, the pattern is still very clear, even though the colors are somewhat faded. The ground color is a grayish-brown with darker brown blotches outlined in dark brown along the dorsal length of the body. The ventral side has a series of dark brown, squarish blotches along the length of the body. The normal head pattern for this subspecies is very pronounced. The scales are smooth and the vent is not divided. A summary of the snake's measurements follows: length of right head 11.8 mm; length of left head 11.6 mm; width of right head 5 mm; width of left head 4.8 mm; length, junction of heads to tail tip 195 mm; length, junction of heads to vent 148 mm; tail length 47 mm.

The heads diverge in the region of the cervical vertebrae. Fusion occurs in the gular region with a membrane of skin loosely connecting the heads ventrally which gives the area between the heads a webbed appearance. Scalation for the right head is as follows: supralabials 7/7, infralabials 8/8, oculars 1-2, temporals 2-2; for the left head: supralabials 7/7 ,infralabials 6/7, oculars 1-2, temporals 2-3. Each head has a loreal, two nasals, and a nostril lateral. The ventrals number 209 and the subcaudals 48.

There are numerous references on this subject, one of the most common reptile anomalies; however, like most anomalies it is rare in occurence. Belloumini (1949, Mem. Inst. Butantan 28:85-89) lists only six cases in 700,000 snakes in the Institute Butantan records. He also refers to this form of dichocephaly as derodymous, after the classification of the various types of duplication in reptiles proposed by Nakamura (1938, Mem. Coll. Sci. Kyoto Univ., series B, 14: 171-181). Belluomini describes derodymous as double-headed with the vertebral column bifurcate in the cervical region. He also includes in his paper a bibliography of some Latin American publications on this condition. Cunningham (1937, *Axial Bifuriation in Snakes,* Duke Univ. Press, 117 pp.) has made a major study of anomalies of this sort in snakes. Meyer (1958, Herpetologica 14(2):128) notes this occuring in *Heterodon platyrhinos,* and Triplehorn (1955, Copeia (3): 248-9) reports a *Storeria dekayi* with one head and two bodies. Steward (1961, Brit. Jour. Herp. 3(I):18) and Curry-Lindahl (1963, Brit. Jour. Herp. 3(4): 81) note dichocephaly in the European viper, *Vipera b. berus.* Klauber (1956, *Rattlesnakes,* Univ. of Cal. Press, Berkely and Los Angeles, 2 vol.) and Neill (1960, Bull. Phila. Herp. Soc. 8(6): 7) list other species of snakes with this disorder.

I would like to thank Louis Sweger and Robert Koppehele for permission to examine the specimen, and Norman Rathman for the loan of references.

DESIGN CALCULATIONS FOR A SMALL PELTIER REFRIGERATOR

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Introduction

In general, Peltier refrigerators will not be competitive with conventional units until semiconductors are available that have a figure of merit considerably in excess of $3 \times 10^{-3}\ {}^{\circ}C^{-1}$. However, where inital cost and efficiency are of secondary importance, Peltier devices, refrigerators, and air conditioners will be used in special application (1, 2, 3, 4). Peltier refrigerators require less space than vapor compression and absorption systems and are free from vibration since they have no moving parts unless fans are used.

Recently the Carrier Corporation installed 28 thermoelectric air conditioners for heating and cooling the office building of S. C. Johnson & Son at Racine, Wisconsin. Each unit has a heating and cooling capacity of 6000 and 4000 B hr^{-1}, respectively, at design conditions. The late Frank Lloyd Wright designed the building, and its structure was such that the thermoelectric air conditioners could be installed at a cost less than that for conventional equipment and, furthermore, without marring the beauty of the edifice.

The Research Division of the American-Standard Corporation designed, built, and delivered a thermoelectric air conditioner (Fig. 1) to the Engineer Research and Development Laboratory of the Army Corps of Engineers. The unit has a cooling capacity of 6000 B hr^{-1} at design conditions. It consists of four modules each having 100 thermocouples, and the assembly weighs approximately 85 pounds. The above thermoelectric air conditioners are applications of the Peltier heat pump principle where initial cost and efficiency are of secondary importance.

In building Peltier refrigerators and/or electric generators it is necessary to insert metallic connectors (Fig. 2, Fig. 3, and Fig. 4) in the electric circuits (5, 6). According to the law of intermediate metals, "the insertion of an additional metal into any circuit does not alter the whole electromotive force in the circuit, provided the additional metal is entirely at the temperature of the point of the circuit at which it is inserted." The data listed below apply to iron-copper, antimony-bismuth, and bismuth telluride p-n thermocouples when their hot and cold junctions are at 40°C and –5°C, respectively. The low values of the Seebeck coefficient S^{abc} and the figure of merit Z_m

Thermoelements	E_{ab}, μv	S_{abc}, μv °C^{-1}	Z_m, °C^{-1}
Fe - Cu	497	13.7	0.005×10^{-3}
Sb - Bi	5039	109.4	0.363×10^{-3}
$Bi_2 Te_3$ (p-n)	19230	423	2.687×10^{-3}

for iron-copper and antimony-bismuth thermocouples indicate clearly why over 125 years have elapsed since Lenz froze a droplet of water using an antimony-bismuth thermocouple, until a Peltier ice making system (Fig. 5) was manufactured (3, 7).

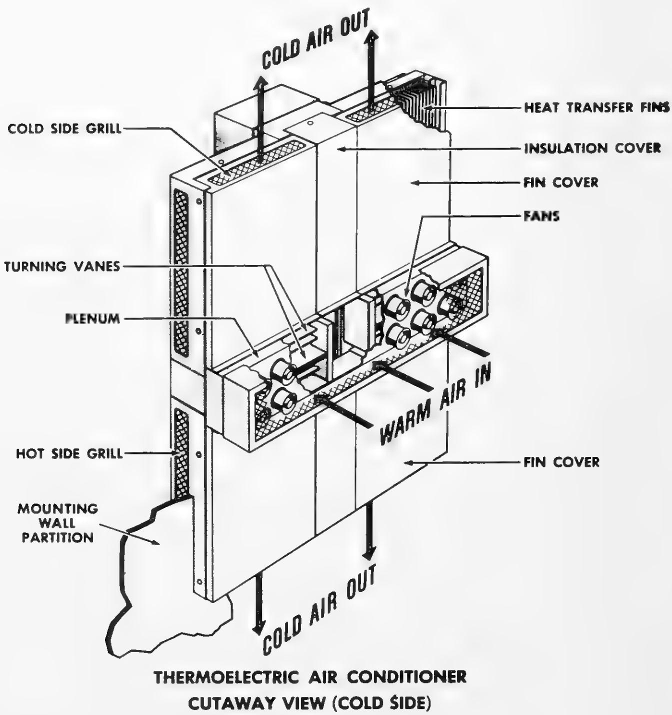

Fig. 1.– "Schematic shows the general configuration and conditioned air circulation for a pre-engineering model air to air thermoelectric air conditioner. This air conditioner was developed for the purpose of evaluating the use of thermoelectric cooling and heating for U.S. Army military vans and shelters. Commander USAERDL, Fort Belvoir, Virginia." Photograph used by permission.

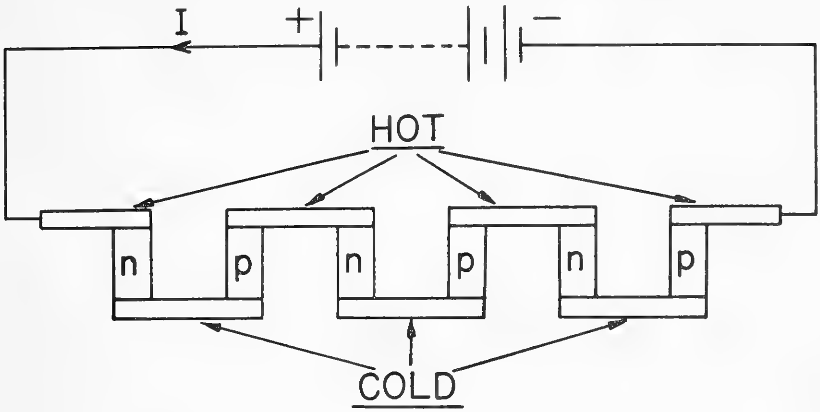

Fig. 2.— A module consisting of three thermocouples connected in electrical series in which heat fluxes are in parallel flow. Additional conducting material is inserted to connect the thermocouple arms.

Derivation of Principal Equations

In Fig. 3 assume that the switch is connected to the battery and that steady state conditions prevail. The system is then a Peltier refrigerator consisting of a single thermocouple that transfers heat power $\dot{Q}$ from a medium at one temperature to another at a higher temperature.* Furthermore assume that the (a) material properties are non-temperature dependent, (b) Thomson heat power and heat power transferred through the lateral surfaces of the thermocouple arms are negligibly small, and (c) the arms are of constant cross-section and equal in length. The Peltier emf's at the hot and cold junctions are $\pi_{abh} = T_h S_{abh}$ and $\pi_{abc} = T_c S_{abc}$,

and the corresponding heat power terms are $\dot{Q}_{abh} = I \pi_{abh}$ and $\dot{Q}_{abc} = I \pi_{abc}$ (Fig. 4). The total emf of the thermocouple is $E_{ab} = S_{ab} (t_h - t_c)$ since $S_{abh} = S_{abc} = S_{ab}$ for the case under consideration (6, 8, 9).

The heat power entering the section of a thermocouple arm (Fig. 1) is $\dot{Q}_x = - k A \dfrac{dt}{dx}$ and that leaving is $\dot{Q}_{x+dx} = \dot{Q}_x + \dfrac{d\dot{Q}_x}{dx} dx = \dot{Q}_x - k A \dfrac{d^2t}{dx^2} dx,$

* See list of principal symbols used.

$$\dot{Q}_x + dx = \dot{Q}_x + \frac{d\dot{Q}_x}{dx}\, dx = \dot{Q}_x - k\, A\, \frac{d^2t}{dx^2}\, dx,$$

neglecting second and higher order terms in the Taylor expansion. The Joule heat power developed within the section is $d\,\dot{Q}_J = \rho\, I^2\, dx / A$. By the first law of thermodynamics the heat power balance is $\dot{Q}_x - \dot{Q}_{x+dx} + d\,\dot{Q}_J = 0$. Substituting equals yields $\frac{d^2t}{dx^2} + \frac{\rho\, I^2}{kA^2} = 0$

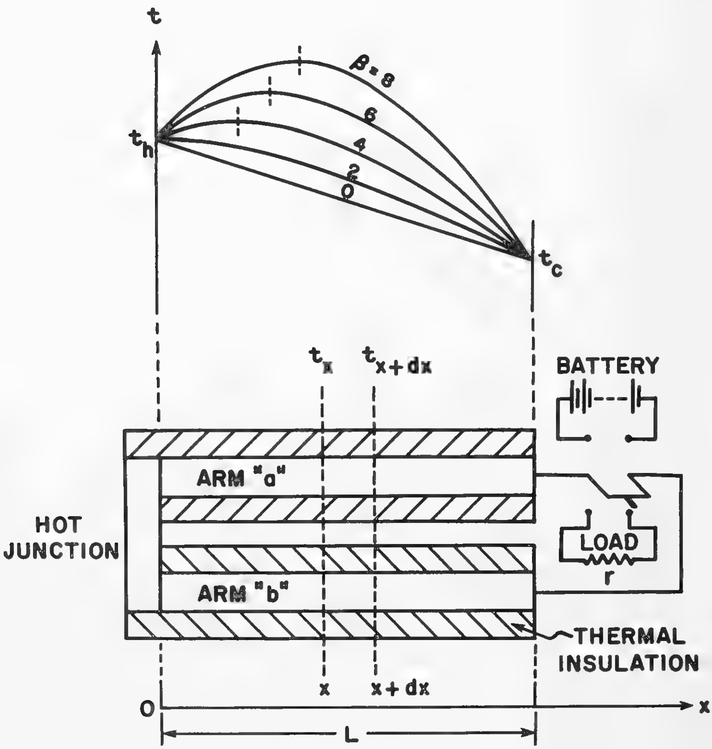

Fig. 3.— Diagram of a Peltier refrigerator and/or thermoelectric generator. The temperatures of the hot and cold junctions are t_h and t_c, respectively. When the switch is connected to the battery the thermocouple is a refrigerator, and when connected to the load it is a generator. As β, the ratio of the Joule heat power to the Fourier heat power, increases from 2 to infinity, maximum of temperature in the thermocouple arms shifts from $x = o$ to $x = L/2$.

Introducing the dimensionless ratios $\zeta = \frac{t}{\Delta t}$ and $\eta = \frac{x}{L}$,

Eq. 1 becomes

$$\frac{d^2\zeta}{d\eta^2} + \frac{L \frac{\rho}{A} I^2}{k A \frac{\Delta t}{L}}, \text{ where } \Delta t = t_h - t_c .$$

Let $\dot{Q}_J = L \frac{\rho}{A} I^2$, $\dot{Q}_F = k A \frac{\Delta t}{L}$, and $\beta = \frac{\dot{Q}_J}{\dot{Q}_F} = \frac{L^2 \rho I^2}{k A^2 \Delta t}$.

Then $\frac{d^2\zeta}{d\eta^2} + \beta = 0$, for either arm. (2)

The general solution of Eq. 1 is $\zeta = c_2 + c_1 \eta - \frac{1}{2} \beta \eta^2$,

or $t = \Delta t \left(c_2 + c_1 \frac{x}{L} - \frac{1}{2} \beta \frac{x^2}{L^2}\right.$. (3)

Applying the boundary conditions $t = t_h$ for $x = o$ and $t = t_c$ for $x = L$ to Eq. 3 gives a particular solution of Eq. 1, namely

$$t = t_h + \Delta t \left\{\left(\frac{\beta}{2} - 1\right) \frac{x}{L} - \frac{1}{2} \beta \frac{x^2}{L^2}\right\}, \tag{4}$$

or

$$t = \left(t_h - \Delta t \frac{x}{L}\right) + \frac{I^2 \rho L^2}{2k A^2} \left(\frac{x}{L} - \frac{x^2}{L^2}\right).$$

The temperature profile for either arm may be obtained by substituting appropriate data in Eq. 4 when the thermocouple functions as a refrigerator or thermoelectric generator.

The temperature gradient in the thermocouple arms is

$$\frac{dt}{dx} = - \frac{\Delta t}{L} \left(1 - \frac{1}{2} \beta + \frac{x}{2}\right), \tag{5}$$

or $$\frac{dt}{dx} = - \frac{\Delta t}{L} + \frac{I^2 \rho L}{2 k A^2} \left(1 - 2 \frac{x}{L}\right).$$

For $\frac{dt}{dx} = 0$, let $x = x_m$ and $t = t_m$. Then

$$x_m = \left(\frac{1}{2} - \frac{1}{\beta}\right) L, \tag{6}$$

or $$x_m = \left(\frac{1}{2} - \frac{k A^2 \Delta t}{I^2 \rho L}\right) L,$$

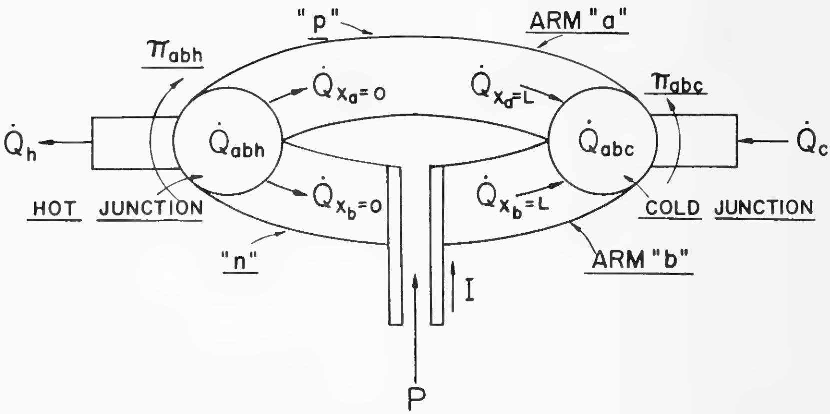

Fig. 4.— Schematic showing a Peltier refrigerator consisting of a single thermocouple with additional metal inserted in the electric circuit. Thermal insulation is not shown. (A) If the hot junction is considered as a thermodynamic system it is evident that $\dot{Q}_{abh} - \dot{Q}_h - \Sigma\dot{Q}_{x=o} = 0$. (b) Similarly, for the cold junction $\dot{Q}_c + \Sigma\dot{Q}_{x=L} - \dot{Q}_{abc} = 0$. (c) Again, if the entire thermocouple is taken as a thermodynamic system $P + \dot{Q}_c - \dot{Q}_h = 0$.

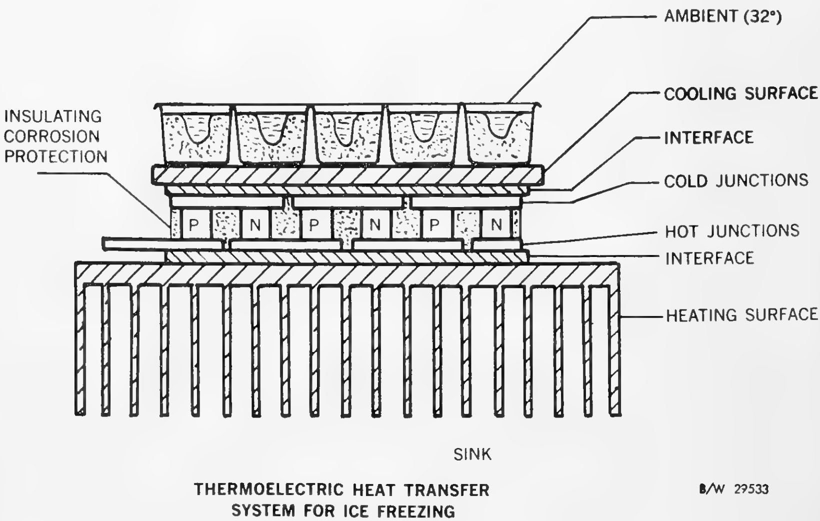

Fig. 5.— Cross-sectional view of one of several modules in a Peltier ice making system. D. C. current enters the p-arms and leaves from the n-arms thereby pumping heat downward through the p-n thermoelements in parallel heat flow, which is transferred to a transport fluid by fins. Courtesy of the York Corporation, York, Pa.

where x_m is the distance from the hot junction to the point of maximum temperature. When the parameter $\beta = 2$, the maximum temperature is at the hot junction (Fig. 3 and Fig. 6), and no Joule heat power is conducted through the thermocouple arm to that junction (10).

Multiplying Eq. 5 by $-$ k A yields

$$\dot{Q}_x = \dot{Q}_F \left(1 - \frac{1}{2}\beta + \beta \frac{x}{L}\right), \tag{7}$$

$$\text{or} \quad \dot{Q}_x = \dot{Q}_F - \frac{1}{2}\dot{Q}_J + \frac{x}{L}\dot{Q}_J .$$

At the hot and cold junctions x equals 0 and L, respectively. Substituting 0 for x in Eq. 7 gives

$$\dot{Q}_{x=o} = \left(1 - \frac{\beta}{2}\right)\dot{Q}_F = \left(\frac{1}{\beta} - \frac{1}{2}\right)\dot{Q}_J = -\frac{I^2 \rho x_m}{A} . \tag{8}$$

Smilarly, substituting L for x in Eq. 7 yields

$$\dot{Q}_{x=L} = \left(1 - \beta/2\right)\dot{Q}_F = \left(1/\beta + 1/2\right)\dot{Q}_J = \frac{I^2 \rho (L - x_m)}{A} \tag{9}$$

Ioffe, Jaumot, and others report *erroneously* that half of the Joule heat power goes to each junction. Eqs. 8 and 9, and Fig 7 show clearly how the Joule heat power splits and the amount of heat power that is conducted to each junction (3, 11, 12). In terms of properties and prescribed conditions Eq. 7 can be written as

$$\dot{Q}_x = k A \frac{\Delta t}{L} - \frac{L \rho I^2}{2 A} + \frac{\rho I^2 x}{A} \tag{10}$$

From Eq. 10 it can be seen that the heat power conducted to the hot and cold junctions, respectively, is given by the equations

$$\dot{Q}_{x=o} = k A \frac{\Delta t}{L} - \frac{L \rho I^2}{2A} , \tag{11}$$

$$\text{and} \quad \dot{Q}_{x=L} = k A \frac{\Delta t}{L} + \frac{L \rho I^2}{2 A} , \tag{12}$$

for each thermocouple arm. For the entire thermocouple Eqs. 11 and 12 can be written as

$$\sum \dot{Q}_{x=o} = \frac{\Delta t}{L} \sum k A - \frac{1}{2} L I^2 \sum \rho / A \tag{13}$$

$$\text{and} \quad \sum \dot{Q}_{x=L} = \frac{\Delta t}{L} \sum k A + \frac{1}{2} L I^2 \sum \rho / A, \tag{14}$$

where $\sum k\,A = k_a\,A_a + k_b\,A_b$ and $\sum \rho/A = \rho_b\,/A_b$.

In Fig. 4 take the hot junction as a thermodynamic system. According to the first law of thermodynamics

$$-\dot{Q}_h + \dot{Q}_{abh} - \sum \dot{Q}_{x=o} = 0, \text{ or } \dot{Q}_h = \dot{Q}_{abh} - \sum \dot{Q}_{x=o} .$$

Therefore, $\dot{Q}_h = I\ \pi_{abh} + \frac{1}{2}\ L\,I^2 \sum \rho\,/A - \frac{\Delta t}{L} \sum k\,A.$ (15)

Similarly, if the cold junction is taken as a thermodynamic system

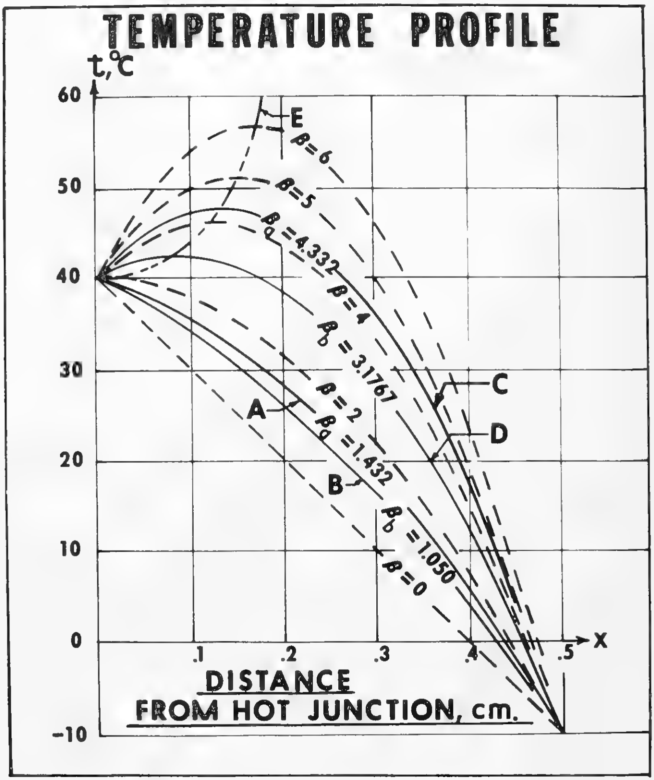

Fig. 6.— Variation of temperature along the thermocouple arms "a" and "b". Curves A and B show the variation of temperature in a design for maximum CER_m, and curves C and D show the variation of temperature in a design for maximum cooling capacity $\dot{Q}_{cm}$. Curve E is the locus of maximum temperature for $2 < \beta < \infty$. The Joule heat power splits at points of maximum temperature for $2 < \beta < \infty$. For $\beta = 2$ none of the Joule heat power is conducted to the hot junction.

β	x_m	t_m	$\left.\frac{dt}{dx}\right]_{x=0}$	$\left.\frac{dt}{dx}\right]_{x=L}$	$\dot{Q}_x = \dot{Q}_F - \frac{1}{2}\dot{Q}_J + \frac{x}{\ell}\dot{Q}_J$ $\dot{Q}_{x=0}$	$\dot{Q}_{x=\frac{L}{2}}$	$\dot{Q}_{x=L}$
∞ $(\Delta t \neq 0)$	$\frac{L}{2}$	$+\infty$	$+\infty$	$-\infty$	$-\infty$	$\dot{Q}_F$	$+\infty$
∞ $(\Delta t = 0)$	$\frac{L}{2}$	$t_h + \frac{I^2 \rho L^2}{8 k A^2}$	$+\frac{I^2 \rho L}{2 k A^2}$	$-\frac{I^2 \rho L}{2 k A^2}$	$-\frac{1}{2}\dot{Q}_J$ $\dot{Q}_F = 0$	$\dot{Q}_F = 0$	$+\frac{1}{2}\dot{Q}_J$ $\dot{Q}_F = 0$
3	$\frac{L}{6}$	$t_h + \frac{\Delta t}{24}$	$+\frac{\Delta t}{2L}$	$-\frac{5\Delta t}{2L}$	$-\frac{1}{6}\dot{Q}_J$ $-\frac{1}{2}\dot{Q}_F$	$\frac{1}{3}\dot{Q}_J$ $\dot{Q}_F$	$+\frac{8}{6}\dot{Q}_J$ $+\frac{5}{2}\dot{Q}_F$
2	0	t_h	0	$-\frac{2\Delta t}{L}$	0 0	$\frac{1}{2}\dot{Q}_J$ $\dot{Q}_F$	$\dot{Q}_J$ $+2\dot{Q}_F$
1.5	$-\frac{L}{6}$	$t_h + \frac{\Delta t}{48}$	$-\frac{\Delta t}{4L}$	$-\frac{7\Delta t}{4L}$	$+\frac{1}{6}\dot{Q}_J$ $+\frac{1}{4}\dot{Q}_F$	$\frac{2}{3}\dot{Q}_J$ $\dot{Q}_F$	$+\frac{7}{6}\dot{Q}_J$ $+\frac{7}{4}\dot{Q}_F$
1.0	$-\frac{L}{2}$	$t_h + \frac{\Delta t}{8}$	$-\frac{\Delta t}{2L}$	$-\frac{3\Delta t}{2L}$	$+\frac{1}{2}\dot{Q}_J$ $+\frac{1}{2}\dot{Q}_F$	$\dot{Q}_J$ $\dot{Q}_F$	$+\frac{3}{2}\dot{Q}_J$ $+\frac{3}{2}\dot{Q}_F$
0.5	$-\frac{3L}{2}$	$t_h + \frac{9\Delta t}{16}$	$-\frac{3\Delta t}{4L}$	$-\frac{5\Delta t}{4L}$	$+\frac{3}{2}\dot{Q}_J$ $+\frac{3}{4}\dot{Q}_F$	$2\dot{Q}_J$ $\dot{Q}_F$	$+\frac{5}{2}\dot{Q}_J$ $+\frac{5}{4}\dot{Q}_F$
0 $(\Delta t \neq 0)$			$-\frac{\Delta t}{L}$	$-\frac{\Delta t}{L}$	$\dot{Q}_J = 0$ $\dot{Q}_F$	$\dot{Q}_F$	$\dot{Q}_J = 0$ $\dot{Q}_F$
0 $(\Delta t = 0)$	—	—	—	—	—	—	—

Fig. 7.— Variation of maximum temperature, temperature gradient, Joule heat power transferred to the hot and cold junctions of a Peltier refrigerator consisting of a single thermocouple versus the coupling parameter β. x_m is the distance of the point of maximum temperature t_m in the thermocouple arms from the hot junction. β is the ratio of the irreversible Joule heat power to the irreversible Fourier heat power.

$$\dot{Q}_c = I\,\pi_{abc} - \frac{1}{2}\,L\,I^2 \sum \rho/A - \frac{\Delta t}{L} \sum k\,A . \tag{16}$$

If the entire thermocouple is taken as a thermodynamic system, then $P + \dot{Q}_c - \dot{Q}_h = 0$, and $P = \dot{Q}_h - \dot{Q}_c$.

Therefore, $P = I\,(\pi_{abh} - \pi_{abc}) + L\,I^2 \sum \rho/A$. (17)

Let $\dot{Q}_c = \dot{Q}_{cm}$ and $I = I_o$ (the optimum current for maximum cooling capacity) for

$$\frac{\partial \dot{Q}_c}{\partial I} = 0. \quad \text{Then}$$

$$I_o = \frac{\pi_{abc}}{L \sum \rho/A}, \tag{18}$$

and $\dot{Q}_{cm} = I_o\,\pi_{abc} - \frac{1}{2}\,L\,I_o^2 \sum \rho/A - \frac{\Delta t}{L} \sum k\,A$. (19)

By definition

$$\text{CER} = \frac{\dot{Q}_c}{P} . \tag{20}$$

Therefore,
$$CER = \frac{I\,\pi_{abc} - \frac{1}{2}\,L\,I^2 \sum \rho/A - \frac{\Delta t}{L} \sum k\,A}{I\,(\pi_{abh} - \pi_{abc}) + L\,I^2 \sum \rho/A} \tag{21}$$

Let
$$CER = \frac{a\,I - \frac{1}{2}\,b\,I^2 - c}{f\,I + b\,I^2}, \tag{22}$$

where $a = \pi_{abc}$, $b = L \sum \rho/A$, $c = \frac{\Delta t}{L} \sum k\,A$ and $f = \pi_{abh} - \pi_{abc}$.

Let $CER = CER_m$ and $I = I_m$, for $\frac{\partial\,(CER)}{\partial\,I} = 0$.

then,
$$I_m = \frac{2\,bc \pm \sqrt{2\,bc\,(2\,af + f^2 + 2\,bc)}}{b\,(2a + f)} \tag{23}$$

and
$$CER_m = \frac{a\,I_m - \frac{1}{2}\,b\,I_m^{\,2} - c}{f\,I_m + b\,I_m^{\,2}} \tag{24}$$

The critical temperature difference between the hot and cold junctions is

$$\Delta t_{cr} = \frac{\pi^2_{abc}}{2 \sum k\,A \,.\, \sum \rho/A} \qquad \text{Eq. 30, ref. 8}$$

The figure of merit and Carnot CER are

$$Z_m = \frac{S_{ab}^{\,2}}{\left(\sqrt{k_a\,\rho_a} + \sqrt{k_b\,\rho_b}\right)^2}, \qquad \text{Eq. 83, ref. 13}$$

and Carnot CER $= \frac{T_c}{T_h - T_c}$, respectively. Eq. 95, ref. 13

Calculations For A Single Stage Refrigerator

Design conditions:

Capacity, 300 watts (1024 B hr^{-1})
Ambient or room air temperature, 35°C (95°F)
Cold chamber temperature, –5°C (23°F)

Prescribed conditions:

Bismuth-telluride (Bi_2Te_3) thermoelements

$S_{ab} = S_{pn} = 424\ \mu v\ °C^{-1}$ (Refer to reference 6)

$L = L_a = L_b = 0.5$ cm

$D = D_a = D_b = 0.7$ cm

$t_h = 40°C$ (104°F)

$t_c = -10°C$ (14°F)

$\Delta t = 50°C$

$$\frac{d^2\zeta}{d\eta^2} + \beta = 0$$

Properties:

$k_a = k_p = 0.0130$ watt $cm^{-1}\ °C^{-1}$

$k_b = k_n = 0.0155$ watt $cm^{-1}\ °C^{-1}$

$\rho_a = \rho_p = 0.00125$ ohm cm

$\rho_b = \rho_n = 0.00110$ ohm cm

Density: p-type $Bi_2Te_3 = 7.4$ gm cm^{-3}

n-type $Bi_2Te_3 = 7.8$ gm cm^{-3}

Values applicable in designs for max. CER_m and max. $\dot{Q}_{cm}$

$T_h = T_o + t_h = 273 + 40 = 313°K$

$T_c = T_c + t_o = 273 - 10 = 263°K$

$A = 0.7854\ D^2 = 0.7854 \times 0.7^2 = 0.3848\ cm^2$

$V = L\ A = 0.5 \times 0.3848 = 0.1924\ cm^3$

$k_a A_a = 0.0130 \times 0.3848 = 0.0050$ watt cm $°C^{-1}$

$k_b A_b = 0.0155 \times 0.3848 = 0.006$ watt cm $°C^{-1}$

$\Sigma k A = 0.005 + 0.006 = 0.011$ watt cm $°C^{-1}$

$\rho_a/A_a = 0.00125 \div 0.3848 = 0.003248$ ohm cm^{-1}

$\rho_b/A_b = 0.0011 \div 0.3848 = 0.002858$ ohm cm^{-1}

$\Sigma\rho/A = 0.003248 + .0002858 = 0.006106$ ohm cm^{-1}

$r = L\sum \rho/A = 0.5 \times 0.006106 = 0.003053$ ohm

$\sqrt{k_a \rho_a} = \sqrt{0.013 \times 0.00125} = 4.0311 \times 10^{-3}$

$\sqrt{k_b \rho_b} = \sqrt{0.0155 \times 0.0011} = 4.1292 \times 10^{-3}$

$$Z_m = \frac{S_{ab}^2}{\left(\sqrt{k_a \rho_a} + \sqrt{k_b \rho_b}\right)^2} = \frac{(424 \times 10^{-6})^2}{(4.0311 \times 10^{-3} + 4.1292 \times 10^{-3})^2} = 2.7 \times 10^{-3}\ {}^{\circ}C^{-1}$$

$$\text{Carnot CER} = \frac{T_c}{T_h - T_c} = \frac{263}{313 - 263} = 5.260$$

$$\pi_{abh} = T_h \; S_{abh} = 313 \times 424 \times 10^{-6} = 0.1327 \text{ volt}$$

$$\pi_{abc} = T_c \; S_{abc} = 263 \times 424 \times 10^{-6} = 0.1115 \text{ volt}$$

$$\Delta t_{cr} = \frac{\pi_{abc}^2}{2 \sum k A \,.\, \sum \rho / A} = \frac{(0.1115)^2}{2 \times 0.011 \times 0.006106} = 92.5412 \,^\circ\mathrm{C}$$

$$\dot{Q}_F\Big)_a = \frac{\Delta t}{L} k_a A_a = \frac{50}{0.5} \times 0.005 = 0.5 \text{ watt}$$

$$\dot{Q}_F\Big)_b \; \frac{\Delta t}{L} k_b A_b = \frac{50}{0.5} \times 0.006 = 0.6 \text{ watt}$$

$$\sum \dot{Q}_F = \frac{\Delta t}{L} \sum k A = \frac{50}{0.5} \times 0.011 = 1.10 \text{ watts}$$

Design calculations for max CER_m:

$$1. \quad I_m = \frac{2bc \pm \sqrt{2bc\,(2af + f^2 + 2bc)}}{b\,(2a + f)} \tag{23}$$

$a = \pi_{abc} = 0.1115$, $b = L \sum \rho/A = 0.5 \times 0.006106 = 0.003053$,

$c = \dfrac{\Delta t}{L} \Sigma\, k\, A = \dfrac{50}{0.5} \times 0.011 = 1.10$, $f = \pi_{abh} - \pi_{abc} = 0.1327 - 0.1115$ $= 0.0212$ and $f^2 = 0.00044944$. Substituting in Eq. 23 gives $I_m =$ 20.9974 amperes for max. CER_m.

2. Joule heat power for entire thermocouple
$\Sigma\, Q_J = L\, I_m^2\, \Sigma\, \rho/A = 0.5 \times (20.9974)^2 \times 0.006106 = 1.3460$ wts

3. Value of parameter β_{ab} for the thermocouple

$$\beta_{ab} = \frac{\sum \dot{Q}_J}{\sum \dot{Q}_F} = \frac{1.3460}{1.10} = 1.2236$$

4. Heat power transferred from hot junction to environment

$$\dot{Q}_h = I_m\, \pi_{abh} + \frac{1}{2} L\, I_m^2\, \Sigma\, \rho/A - \frac{\Delta t}{L} \Sigma\, k\, A \tag{15}$$

$$\dot{Q}_h = 20.9974 \times 0.1327 + \frac{1}{2} \times 0.5 \times (20.9974)^2 \times 0.006106 - \frac{50}{0.5} \times 0.011 = 2.3593 \text{ watts}$$

5. Peltier heat power developed at the hot junction

$$\dot{Q}_{abh} = I_m \pi_{abh} = 20.9974 \times 0.1327 = 2.7863 \text{ watts}$$

6. Peltier heat power developed at the cold junction

$$Q_{abc} = I_m \pi_{abc} = 20.9974 \times 0.1115 = 2.3452 \text{ watts}$$

7. Heat power transferred from cold chamber to cold junction

$$\dot{Q}_c = I_m \pi_{abc} - \frac{1}{2} L I_m^2 \Sigma \rho/A - \frac{\Delta t}{L} \Sigma k A \qquad (16)$$

$$\dot{Q}_c = 20.9974 \times 0.1115 - \frac{1}{2} \times 0.5 \times (20.9974)^2 \times 0.006106 - \frac{50}{0.5} \times 0.011$$

$$\dot{Q}_c = 0.5722 \text{ watt}$$

8. Power supplied for max. CER

$$P = I_m (\pi_{abh} - \pi_{abc}) + L I_m^2 \Sigma \rho/A \qquad (17)$$

$$P = 20.9974 (0.1327 - 0.1115) + 0.5 (20.9974)^2 \times 0.006106 = 1.7911 \text{ watts}$$

9. Maximum cooling energy ratio

$$CER_m = \frac{\dot{Q}_c}{P}$$

$$CER_m = \frac{0.5722}{1.7911} = 0.3195 \text{ versus Carnot CER} = 5.26$$

10. Thermocouples required for max. CER_m
300 watts ÷ 0.5722 watts couple^{-1} = 524 thermocouples
Use 6 modules each containing 100 thermocouples

11. Mass of p-type $Bi_2 Te_3$ thermoelements
$V = A L = 0.3848 \text{ cm}^2 \times 0.5 \text{ cm} = 0.1924 \text{ cm}^3$
$M_p = 7.4 \times 0.1924 = 1.4238$ grams/thermocouple
Total mass = 1.4238 × 600 = 854.28 grams

12. Mass of n-type $Bi_2 Te_3$ thermoelements
$M_n = 7.8 \times 0.1924 = 1.4997$ grams/thermocouple
Total mass = 1.4997 × 600 = 899.82 grams

Design calculations for max. $\dot{Q}_{cm}$:

1. $$I_o = \frac{\pi_{abc}}{L \Sigma \rho/A} \qquad (18)$$

$$I_o = \frac{0.1115}{0.5 \times 0.006106} = 36.5215 \text{ amperes and } I_o^2 = 1333.82$$

2. Joule heat power for entire thermocouple

$$\Sigma \dot{Q}_J = L\,I_o^2\,\Sigma\,\rho/A = 0.5 \times 1333.82 \times 0.006106 = 4.0722 \text{ watts}$$

3. Value of parameter β_{ab} for the entire thermocouple

$$\beta_{ab} = \frac{\sum \dot{Q}_J}{\sum \dot{Q}_J} = \frac{4.0722}{1.10} = 3.7020$$

4. Heat power transferred from hot junction to environment

$$\dot{Q}_h = I_o\,\pi_{abh} + \frac{1}{2} L\,I_o^2\,\Sigma\,\rho/A - \frac{\Delta t}{L}\,\Sigma\,k\,A \tag{15}$$

$$\dot{Q}_h = 36.5215 \times 0.1327 + \frac{1}{2} \times 0.5 \times 1333.82 \times 0.006106 - \frac{50}{0.5} \times 0.011$$

$$\dot{Q}_h = 5.7825 \text{ watts}$$

5. Peltier heat power developed at the hot junction

$$\dot{Q}_{abh} = I_o\,\pi_{abh} = 36.5215 \times 0.1327 = 4.8464 \text{ watts}$$

6. Peltier heat power developed at the cold junction

$$\dot{Q}_{abc} = I_o\,\pi_{abc} = 36.5215 \times 0.1115 = 4.0721 \text{ watts}$$

7. Heat power transferred from cold chamber to cold junction

$$\dot{Q}_{cm} = I_o\,\pi_{abc} - \frac{1}{2} L\,I_o^2\,\Sigma\,\rho/A - \frac{\Delta t}{L}\,\Sigma\,k\,A \tag{16}$$

$$\dot{Q}_{cm} = 36.5215 \times 0.1115 - \frac{1}{2} \times 0.5 \times 1333.82 \times 0.006106 = 0.9360 \text{ watt}$$

8. Power supplied for max. $\dot{Q}_{cm}$

$$P = I_o\,(\pi_{abh} - \pi_{abc}) + L\,I_o^2\,\Sigma\,\rho/A \tag{17}$$

$$P = 36.5215 \times 0.0212 + 0.5 \times 1333.82 \times 0.006106 = 4.8465 \text{ wts.}$$

9. Cooling energy ratio

$$CER = \frac{Q_{cm}}{P} \tag{20}$$

$$CER = \frac{0.9360}{4.8465} = 0.1931 \text{ versus Carnot CER} = 5.26$$

10. Thermocouples required for max. $\dot{Q}_{cm}$
300watts $\div$ 0.9360 watts couple^{-1} = 320.51 thermocouples
Use 4 modules each containing 100 thermocouples

11. Mass of p-type Bi_2Te_3 thermoelements
$M_p = 7.4 \times 0.1924 = 1.4238$ grams/thermocouple
$400 \times 1.4238 = 569.52$ grams

12. Mass of n-type Bi_2Te_3 thermoelements
$M_n = 7.8 \times 0.1924 = 1.4997$ grams/thermocouple
Total mass $= 400 \times 1.4997 = 599.88$ grams

Temperature profile for max. CER_m *or* $I_m = 20.9974$ *amperes*

For arm "a", $\left.\dot{Q}_F\right)_a = \frac{\Delta t}{L} k_a A_a = \frac{50}{0.5} \times 0.005 = 0.500$ watt

$$\left.\dot{Q}_J\right)_a = L I_m^2 \frac{\rho_a}{A_a} = 0.5\,(20.9974)^2 \times 0.003248 = 0.716 \text{ watt}$$

$$\beta_a = \left.\frac{\dot{Q}_J}{\dot{Q}_F}\right]_a = \frac{0.716}{0.500} = 1.4320$$

$$x_m = \left(\frac{1}{2} - \frac{1}{\beta_a}\right) L \qquad (6)$$

$$x_m = \left(\frac{1}{2} - \frac{1}{1.432}\right) \times 0.5 = -0.0992 \text{ cm (there is no real max. temp.)}$$

$$\dot{Q}_{x=o} = \left(\frac{1}{\beta_a} - \frac{1}{2}\right) \dot{Q}_J \qquad (8)$$

$$\dot{Q}_{x=o} = \left(\frac{1}{1.432} - \frac{1}{2}\right) \times 0.716 = +0.142 \text{ watt.}$$

Joule heat power (0.716) is conducted away from the hot junction, i.e., in the positive χ – direction. To check, use

$$\dot{Q}_{x=o} = -I_m^2 \frac{\rho_a}{A_a} x_m = -(20.9974)^2 \times 0.003248\,(-0.0992) = +0.142 \text{ watt.}$$

$$\dot{Q}_{x=L} = \left(\frac{1}{\beta_a} + \frac{1}{2}\right) Q_J \qquad (9)$$

$$\dot{Q}_{x=L} = \left(\frac{1}{1.432} + \frac{1}{2}\right) \times 0.716 = +0.858 \text{ watt.}$$

Thus 0.142 + 0.716, or 0.858 watt is conducted through arm "a" to the cold junction.

The temperature profile is $t_a = t_h + \Delta t \left\{ \left(\frac{\beta_a}{2} - 1\right) \frac{x}{L} - \frac{\beta_a}{2} \frac{x^2}{L^2} \right\}$ (4)

$$t_a = 40 + 50 \left\{ \left(\frac{1.432}{2} - 1 \right) \times \frac{x}{0.5} - \frac{1.432}{2} \times \frac{x^2}{0.25} \right\}, \text{ or}$$

$$t_a = 40 - 28.4x - 143.2x^2, \ ^\circ\text{C.} \quad \text{(See Curve A, Fig. 3).}$$

In like manner the following results were obtained *for arm "b"*:

$\dot{Q}_F = 0.600$ watt, $\dot{Q}_J = 0.630$ watt

$\beta_b = 1.050$, $x_m = -0.2262$ cm, $\dot{Q}_{x=o} = 0.285$ watt, $\dot{Q}_{x=L} = 0.915$ watt, and $t_b = 40 - 47.5x - 105.0\,x^2$, °C. (See Curve B, Fig. 6)

Temperature profile for max. $\dot{Q}_{cm}$ *and* $I_o = 36.5215$ *amperes*:

Calculations, similar to those for CER_m, were made for $\dot{Q}_{cm}$ and the results are listed below.

Item	Arm "a"	Arm "b"
$\dot{Q}_F$, watts	0.500	0.600
$\dot{Q}_J$, watts	2.1661	1.9060
β	4.3322	3.1767
x_m, cm	0.1346	0.0926
$\dot{Q}_{x=o}$, watts	−0.5830	− 0.3530
$\dot{Q}_{x=L}$, watts	1.5830	1.5530

$t_a = 40 + 116.61\,\chi - 433.22\,x^2$, °C (See Curve C, Fig. 6)
$t_b = 40 + 58.835\,\chi - 317.67\,x^2$, °C (See Curve D, Fig. 6)

Discussion

The operating current is 20.9974 amperes in the *design for maximum cooling energy ratio.* The cooling energy ratio and cooling capacity are 0.3195 and 0.5722 watt, respectively. There is no heat power conducted through either thermocouple arm to the hot junction, that is, there is no splitting of the Joule heat power, and $1 < \beta < 2$ (Fig. 6 and Fig. 8). In the *design for maximum cooling capacity* the operating current is 36.5215 amperes. The cooling energy ratio and cooling capacity are 0.1931 and 0.9360 watt, respectively. The Joule heat power splits in arms "a" and "b", respectively, at 0.1346 and 0.0926 cm from the hot junction and $2 < \beta < \infty$ for either arm. In arm "a" 26.92% of the Joule heat power is conducted to the hot junction and 73.08% is conducted to the cold junction; in arm "b" 18.52%

of the Joule heat power is conducted to the hot junction and 81.48% is conducted to the cold junction. The temperature profile is given for several values of β in Fig. 6. The amount of bismuthtelluride in the design for maximum cooling energy ratio and maximum cooling capacity is 1754.10 and 1169.40 grams, respectively.

The performance of the single thermocouple, operating as a highly idealized Peltier refrigerator is presented graphically in Fig. 8 to Fig. 12, inclusive. The variation in cooling capacity and cooling energy ratio with current is presented in Fig. 8. Operating with an electric current greater than I_0 produces cooling with a waste in power input. The cooling capacity is zero for currents of 11.7606 and 61.2823 amperes. Fig. 9 shows that the Fourier heat power is independent of the strength of the supply current, and that total heat power for the entire thermocouple is conducted to the hot junction for $27 < I \leq 61.2823$ amperes and away from it for $11.7606 < I < 27$ amperes.

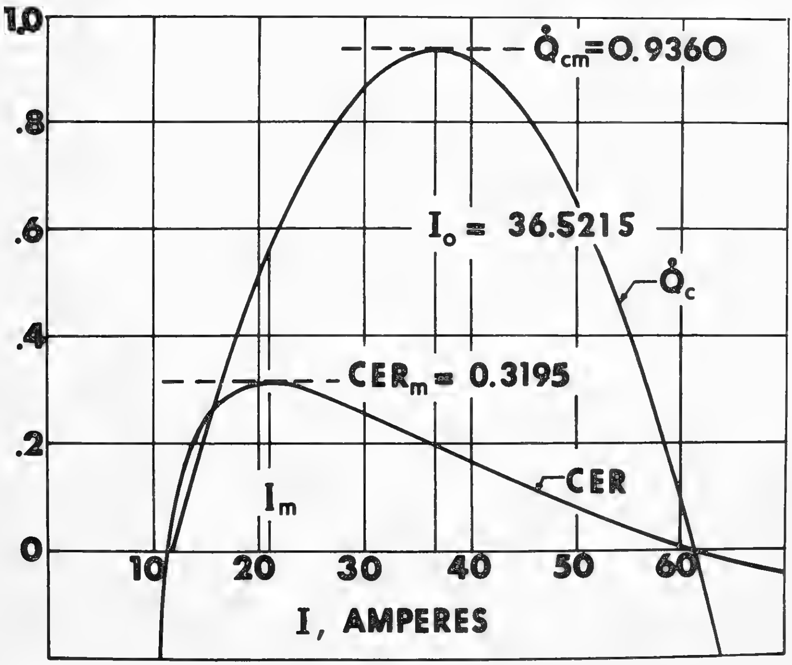

Fig. 8.— Variation of the cooling capacity (in watts) and cooling energy ratio with electric current. Results obtained in the design for maximum cooling are:

$\dot{Q}_{cm} = 0.9360$ watt, $I_0 = 36.5215$ amperes, $P = 4.8465$ watts, and $CER_0 = 0.1931$.

Results obtained indesign for maximum cooling energy ratio are: $\dot{Q}_c = 0.5722$ watt, $I_m = 20.9974$ amperes, $P = 1.7911$ watts, and $CER_m = 0.3195$.

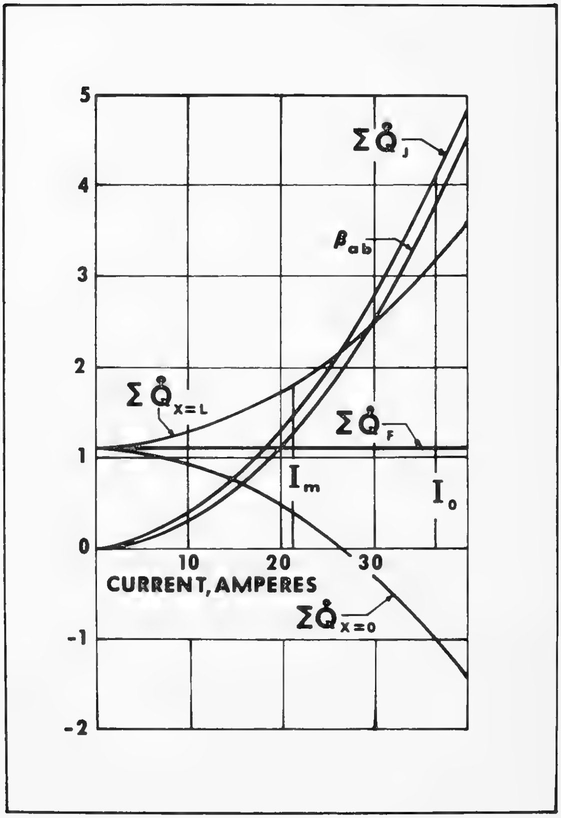

Fig. 9.—Variation of $\Sigma\dot{Q}$ and β_{ab} with I. $\Sigma\dot{Q}_{x=o} = 0$ and $I = 26.844$ amperes for $\beta_{ab} = 2$. $\Sigma\dot{Q}_F = 1.1$ watts for all values of I. For $\beta_{ab} < 2$, $\Sigma\dot{Q}_{x=o} > 0$ and $\Sigma\dot{Q}_{x=o} < 0$ for $2 < \beta_{ab} < \infty$.

Joule heat power, heat power conducted to the cold junction increases rapidly with increase in supply current. As Δt increases from zero to the critical Δt (Fig. 10), the current for maximum cooling energy ratio approaches the current for maximum cooling and for $\Delta t_{cr} = 92.5412$ °C, $I_m = I_o$. Also, as Δt increases, the cooling energy ratios decrease very rapidly. In Fig. 11 the solid lines are constant Δt curves which show the variation of the cooling energy ratio with current, and the dashed-curve is the locus of maximum CER.

Fig. 12 presents curves of constant current and constant cooling energy ratio on a $\Delta t - \dot{Q}_c$ plane. As an application of Fig. 12 consider, for example, a design for maximum cooling energy ratio in which the design and prescribed conditions remain constant. The calculated values of the supply current, cooling capacity, and maximum cooling energy ratio were found to be 20.9974 amperes, 0.5722 watt, and 0.3195, respectively. If, however, the supply current is reduced to 15 amperes, the cooling capacity and cooling energy ratio are reduced to about 0.23 watt and 0.23, respectively. If on the other hand, the supply current is kept at the design value of 20.9974 amperes and the ambient temperature is increased to such a value that Δt is changed from 50 to 60°C, then the cooling capacity and cooling energy ratio

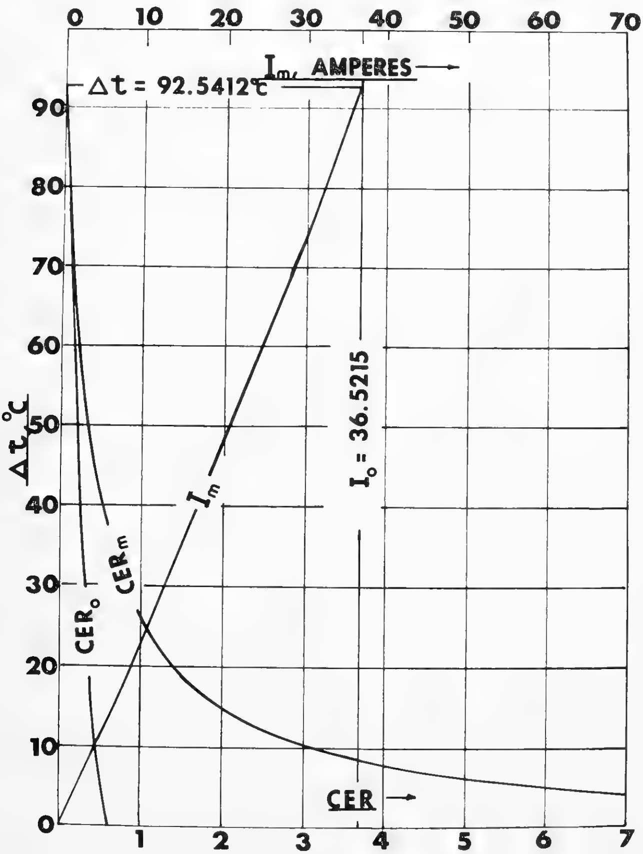

Fig. 10.—Variation of CER_m and CER_o with Δt, where $\Delta t = t_h + 10$, °C. For the prescribed conditions $\Delta t = 50$°C, $CER_m = 0.3195$ and $\dot{Q}_{cm} = 0.9360$ watt. Operating at $\Delta t > 50°$, CER_m and CER_o are less than their design values; operating at $\Delta t < 50°$, CER_m and CER_o are greater than their design values.

will be reduced from 0.5722 to 0.34 watt, and 0.3195 to 0.18, respectively.

Conclusions

A highly idealized Peltier refrigerator was analyzed in which the Thomson effect and heat power leakage through the lateral surfaces of the thermoelements were neglected. Six modules, each having 100 p-n type bismuth telleride thermocouples will produce a cooling capacity of 300 watts at a $CER_m = 0.3195$. In the design for maximum cooling capacity four modules, each having 100 thermocouples will produce a cooling capacity of 300 watts at a CER = 0.1931. Variations from either of the two designs that were considered are presented graphically by use of performance curves.

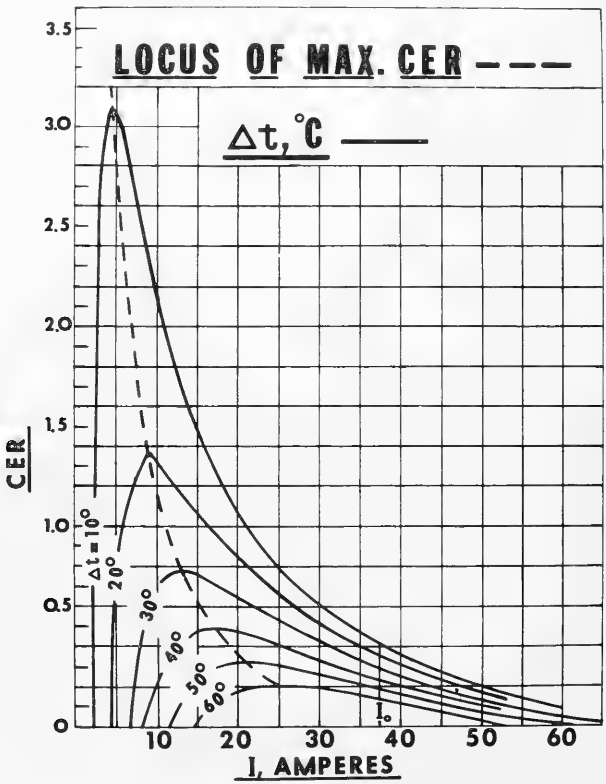

Fig. 11.—Constant Δt curves for $\Delta t = t_h + 10$, °C. The design and prescribed conditions are for the Peltier refrigerator operating at $\Delta t = 50$°C.

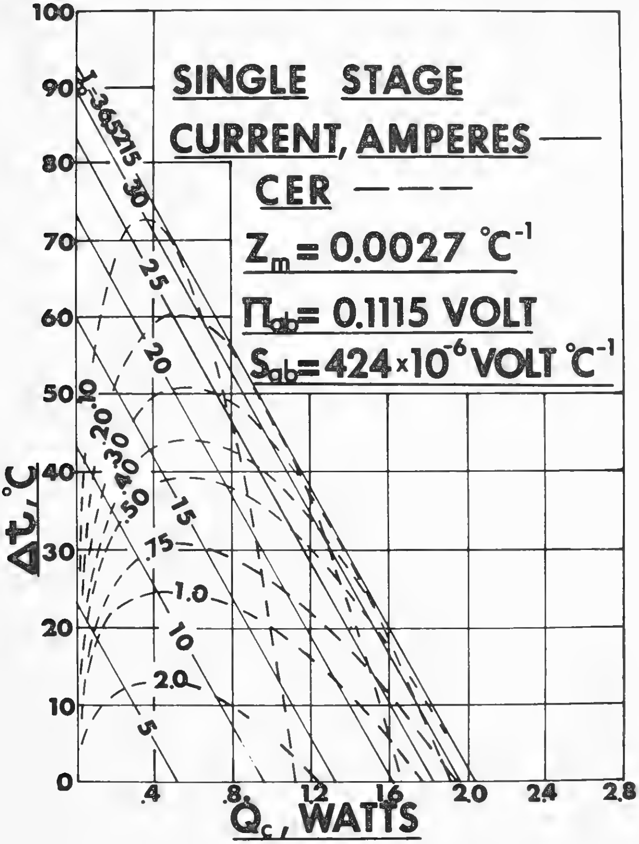

Fig. 12.— Curves of constant electric current and constant cooling energy ratio on a $Q_c - \Delta t$ plane. For $CER_m = 0.3195$: $I_m = 20.9974$ amperes, $Q_c = 0.5722$ watt, $\Delta t = 50°C$. For $\dot{Q}_{cm} = 0.9360$ watt: $I_o = 36.5215$ amperes, $CER_o = 0.1931$, $\Delta t = 50°C$.

Principal Symbols Used

A — area
CER — cooling energy ratio
CER_m — maximum cooling energy ratio
CER_o — cooling energy ratio for maximum cooling capacity
D — diameter
E_{ab} — total emf of the thermocouple
I_m — electric current for maximum CER
I_o — electric current for maximum $\dot{Q}_c$

L – length
P – electric power
Q – heat
$\dot{Q}$ – $\frac{dQ}{d\tau}$, heat power
$\dot{Q}_{abc}$ – Peltier heat power developed at the cold junction
$\dot{Q}_{abh}$ – Peltier heat power developed at the hot junction
$\dot{Q}_{c}$ – heat power from cold chamber to cold junction
$\dot{Q}_{h}$ – heat power from hot junction to room air (ambient)
$\dot{Q}_{F}$ – Fourier heat power
$\dot{Q}_{J}$ – Joule heat power
S_{ab} – Seebeck coefficient
S_{abc} – Seebeck coefficient at the cold junction
S_{abh} – Seebeck coefficient at the hot junction
T_{c} – absolute temperature at the cold junction, °K
T_{h} – absolute temperature at the hot junction, °K
V – volume
Z_{m} – figure of merit
a – π_{abc}
b – $L \Sigma \rho/A$
c – $\frac{\Delta t}{L} \Sigma k A$
f – $\pi_{abh} - \pi_{abc}$
k – thermal conductivity
t_{c} – cold junction temperature, °C
t_{h} – hot junction temperature, °C
x – distance from hot junction along thermocouple
x_{m} – distance from hot junction to point of max. temp.
β_{a} – $\dot{Q}_{J} \div \dot{Q}_{F}$ for thermocouple arm "a"
β_{b} – $\dot{Q}_{J} \div \dot{Q}_{F}$ for thermocouple arm "b"
β_{ab} – $\dot{Q}_{J} \div \dot{Q}_{F}$ for entire thermocouple
Δt – $t_{h} - t_{c}$, °C
Δt_{cr} – critical Δt
ζ – dimensionless ratio $\frac{t}{\Delta t}$

η — dimensionless ratio $\frac{x}{L}$

π_{abc} — Peltier emf at the cold junction

π_{abh} — Peltier emf at the hot junction

ρ — resistivity

μv — micro volt

τ — time

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ACADEMY AFFAIRS

Minutes of the Fall 1965 Annual Business Meeting

The Annual Business Meeting of the Kentucky Academy of Science was called to order by President Hamann on Saturday Morning, November 13, 1965 in Room N-10 of the Agricultural Science Center of the University of Kentucky.

The minutes of the 1964 meeting were read and approved.

A list of new members was read for approval by the academy. The list included:

Arthur L. Applegate
I. T. Baldwin
Donald Batch
William G. Bos
David Brumagen, Jr.
Betty M. Burchett
Bruce D. Burton
Rolene B. Cain
Sister Martha Ann Cargill, O.S.U.
Thomas H. Crawford
Mrs. J. M. Edney
Harold Eversmeyer
Ellis Fernald
Irving S. Fisher
Sara H. Frye
James Hall, Jr.
Judy Hamilton
Bessie Hendrixsen
James W. Hendrix
Bernice Hinshaw
Chester C. Irvin
Charles Isbell
Merton W. Jones
Dorothy K. Lauder
Zelek L. Lipchinsky
William C. MacQuoun, Jr.
John L. Mersenheimer
John G. Nickum
D. Hugh Puckett
Orville Richardson, Jr.
Donald B. Sands
Howard L. Setser
George C. Simmons
William G. Simpson
Wynema Sims
June Sisk
Dorothy Tapp
Gordon W. Weir
William B. Wilder
W. A. Withington

The new members were approved.

The treasurer's report was given by J. Garner. It was moved and seconded that the report be accepted. The motion carried.

E. N. Fergus reported for the Visiting Scientists Program. He indicated that the number of visits requested by high school teachers last year were not as great as anticipated. Requests this year are running ahead of last year since to date there are 69 compared with 21 at this time one year ago. This year's publicity was sent directly to the high school science teachers. The roster of available visiting scientists includes approximately 150 names. The present director of the program is resigning. An application to the National Science Foundation has been made to continue the program for another year.

President Hamann expressed the appreciation of the academy for the work of Dr. Fergus, as director of the Visiting Scientists Program for the past two years.

President Hamann noted that R. Jordan has resigned as Director of the Junior Academy, but is present to give his report of last year's activities. His report, as accepted by the academy is attached to the minutes.

W. Owsley invited the academy to Kentucky Wesleyan College for next year's annual meeting. J. Carpenter noted that the Centennial Celebration for T. H. Morgan is scheduled for Lexington next year. It was moved and seconded that the place for next year's meeting be left in the hands of the executive committee. Motion carried.

M. Wharton reported on the annual meeting of the American Association for the Advancement of Science meeting at Montreal, Canada. She noted that the state academies of several nearby states are considerably larger and stronger than our academy. Perhaps one of our greater needs is that of a permanent officer, such as an executive secretary or archives. She commented on the role of the state academy and teacher certification. Many states have fewer requirements concerning "education courses" and thus students are able to take more work in "content" material. Dr. Wharton reported that she will be unable to attend the next Annual AAAS Meeting, and suggested that our President-elect, J. Carpenter, be our official representative. Motion was seconded and carried.

President Hamann reported on the difficulties previously encountered in the receipt of a $5,000 grant from the Department of Education, to our academy, for the Junior Academy and Science Youth Work. He noted the establishment of a Science Youth Activity Committee by F. Dickey. The only present representative of the original committee is D. Tapp.

President Hamann noted the lack of support of our academy by industry; probably only 3 industries are currently active. The possibility of academy support from the State Government level was raised.

It was moved and seconded that the Executive Committee of the Kentucky Academy of Science be given authority to work on the above problems, and report at the next annual meeting. Motion carried.

H. LaFuze, chairman of the Resolutions Committee, read the following resolutions:

I. Whereas, the life of Dr. Alfred Brauer was taken on January 26, 1965,

   Whereas, Dr. Brauer gave 50 years of his life to successful teaching and to inspiring his many students toward high goals, Whereas, Dr. Brauer was nationally recognized for his research in biology as evidenced by his publication,

Whereas, Dr. Brauer was a member of the Kentucky Academy of Science for 38 years and served in various offices of the Academy for thirteen years,

Whereas, Dr. Brauer contributed freely of his time and efforts to the promotion of science and the Academy in all of the years of his association with it,

be it hereby resolved

1. that those present in this meeting of the Kentucky Academy of Science stand for a moment of silent tribute in memory of this great teacher and scientist who has passed from us,
2. that these resolutions be included in the minutes of this meeting and a copy be sent to his surviving wife.

II. Whereas, the University of Kentucky is celebrating its Centennial Year, and

Whereas, the University of Kentucky has made outstanding contributions in scientific thought and leadership.

be it hereby resolved

1. that we, the Kentucky Academy of Science, congratulate the University for its one hundred years of service as an outstanding institution of higher education in Kentucky and our nation and for the promotion of science through teaching research,
2. that we, the Kentucky Academy of Science, commend the faculty and the administration who have made this progress possible,
3. that these resolutions be included in the minutes of this meeting and a copy be sent to the office of the president of the university.

It was moved and seconded that the academy accept these resolutions. Motion carried.

The nominating committee, W. Blackburn, F. Gailey, and H. Nollau, presented the following slate of nominees:

President-elect—R. Boyer
Vice-president—W. Read
Secretary—D. Lindsay

Treasurer—C. Hamann
Representative to AAAS Council—M. Wharton
Board of Directors—M. Heaslip, L. Alexander

It was moved and seconded that the secretary cast a unanimous ballot for all nominees. Motion carried.

E. Browne reported on the status of the Kentucky Flora Project. He noted that work is in progress in various regions of the state and that G. Hunter has been added to the original committee. The report was accepted by the academy, with thanks.

The academy gave a vote of approval to the work of the past officers.

The meeting was adjourned at 12:15 P.M.

Dwight M. Lindsay, Secretary

The officers who were elected at the sectional meetings are as follows:

Microbiology
Jack N. Baldwin, Chairman
Grace Quinto, Secretary

Botany
Harold Eversmeyer, Chairman
Robert Larance, Secretary

Geology and Geography
Zelek L. Lipchinsky, Chairman
David K. Hylbert, Secretary

Psychology
Mary Ellen Curtis, Chairman
Richard M. Griffith, Secretary

Zoology
Lloyd Alexander, Chairman
Liza Spann, Secretary

Treasurer's Report for 1964-65

Balance in checking account, Second National Bank Lexington, Kentucky, October 1, 1964		$ 608.39
Income October 1, 1964 to October 1, 1965		
Regular Membership dues	$ 871.50	
Industrial membership dues	500.00	
Sustaining membership dues	250.00	
Subscriptions to Transactions of K.A.S.	272.50	
Sale of reprints	71.50	
Overhead from Visiting Scientists Program	483.29	
Refund from U.S. Government on Income Tax	44.71	
Total Income	$2,493.50	$3,101.89
Expenditures October 1, 1964 to October 1, 1965		
Secretary's expenses	$ 156.69	
Treasurer's expenses	15.00	

Kentucky Junior Academy of Science	729.33	
Kentucky Science Talent Search	56.85	
Visiting Scientists Program	170.94	
Corporation Fees, Kentucky Department of State	2.00	
Banquet Speaker, Fall Banquet	57.21	
Academy Conference Dues	7.00	
A.A.A.S. Organization Assessment	10.00	
A.A.A.S. Meeting—Delegates expenses	150.00	
Total Expenses	1,355.02	
Balance in checking account on October 1, 1965		$1,746.87
Balance in savings account, Lexington Federal		
Savings and Loan Association October 1, 1964	$ 709.25	
Interest October 1, 1964 to October 1, 1965	28.66	
Balance in savings account October 1, 1965		$ 737.91
Balance in Thomas Hunt Morgan Fund in First Federal		
Savings and Loan Association October 1, 1965	$ 75.21	
Interest October 1, 1964 to October 1, 1965	3.02	
Balance in Thomas Hunt Morgan Fund		$ 78.23

Sectional Meetings

BOTANY SECTION

Agricultural Science Center—Room N-208

J. H. B. Garner, Chairman
Gordon E. Hunter, Secretary

1. Jane S. Sisk. Department of Biological Sciences, Murray State College. A partial list of edible spermatophytes of Calloway County, Kentucky.
2. H. E. Eversmeyer. Department of Biological Sciences, Murray State College. Anatomy of *Paeonia albiflora* roots.
3. S. K. Majumdar and H. P. Riley. Department of Botany, University of Kentucky. Polyploidy and the evolution of its role in *Haworthia.*
4. G. E. Hunter. Department of Biological Sciences, Murray State College. Chromatographic documentation of interspecific hybridization in *Vernonia*: Compositae.
5. G. E. Hunter and D. F. Austin. Department of Biological Sciences, Murray State College. Evidence from trichome morphology of interspecific hybridization in *Vernonia*: Compositae.
6. E. T. Browne, Jr. Department of Botany, University of Kentuckyl. The vascular flora of Pike County, Kentucky.
7. R. E. Hampton. Departments of Botany and Plant Pathology, University of Kentucky. Intracellular distribution of polyphenol oxidase in *Nicotiana tabacum* and *Zea maize.*

CHEMISTRY SECTION

Agricultural Science Center—Room N-320

Darnell Salyer, Chairman
N. Thornton Lipscomb, Secretary

1. "Thermal Rearrangement Products of Cycloalkano (a) pyrroles," John M. Patterson and Soekani Soedigdo, University of Kentucky.
2. "Some Approaches to the Synthesis of Nitro Amines," John M. Patterson, Richard Johnson, and Michael W. Barnes, University of Kentucky.
3. "Solvent Dependence of Geminal Proton-Proton Coupling Constants," Richard H. Cox and Stanford L. Smith, University of Kentucky.
4. "Nuclear Magnetic Resouance Spectroscopy. A Study in Magnetic Non-equivalence," Richard H. Wiley, Thomas H. Crawford, J. M. McIntire, and H. L. Puckett, University of Louisville.
5. "Thermal Decomposition of Some Copolymers," Richard H. Wiley, Giovanni DeVenuto, and Frank E. Martin, University of Louisville.
6. "Characterization of Solvent-Modified Cation Exchange Resins," Richard H. Wiley and J. Thomas Badgett, University of Louisville.
7. "Azo Coupling in the Quinoline Series," James J. Duffy and Ellis V. Brown, University of Kentucky.
8. "Determination of Trace Amounts of Antimony by Neutron Activation," J. T. Tanner and W. D. Ehmann, University of Kentucky.
9. "Bromine in Natural Materials by Activation Analysis," K. W. Lieberman and W. D. Ehmann.
10. "A Ternary Vapor-Liquid Equilibrium System Methanol-Benzene-Toluene," D. E. Burke and G. C. Williams, University of Louisville.

GEOLOGY AND GEOGRAPHY SECTION

Agricultural Science Center—Room N-11

Zelek L. Lipchinsky, Chairman
David K. Hylbert, Secretary

1. Gordon W. Weir,* J. L. Gualtieri, and S. O. Schlanger, "Borden Formation (Mississippian) in South- and Southeast-Central Kentucky." Time about 20 minutes using 2X2 and 3¼″ slides.
2. George C. Simmons,* "Pre-Middle Devonian and post-Middle Devonian faulting and the Silurian-Devonian unconformity near Richmond, Kentucky." Time about 10 minutes using 3¼″ slides.
3. James E. Conkin and Barbara M. Conkin, "Foraminiferal Zonation of the Permian System of Tasmania."
4. Willard R. Jillson,* a list of four short papers follows:
   a. "A Rare Iron Conglomerate, Occurring in Northeastern Hardin County, Kentucky."
   b. "*Lin gula nedularata,* Sp. Nov., Occurring in Central Powell County, Kentucky."
   c. "A Limestone Conglomerate Occurring in the Eden Formation of Clark County, Kentucky."
   d. "Fish Coprolites in the Onondaga Limestone of Eastern Central Kentucky."

   Times for above papers about 20 to 30 minutes.

5. Larry Ratcliff,*Thomas Sanders, J. R. Chaplin, and Allen Lake, "The Progress Report on the Study of Stigmarian Root System in Elliott County, Kentucky." Time about 20 minutes using 35 mm slides.

MICROBIOLOGY SECTION

Agricultural Science Center—Room N-8

Lucia Anderson, Chairman
J. N. Browning, Secretary

1. Protection of mice against Vesicular Stomatitis with homologous brain tissue vaccines. Mary B. Althauser and Isaac Ruchman, Department of Microbiology, University of Kentucky, Lexington.
2. The Nature of some beta-hemolysin mutants of *Staphylococcus aureus.* W. E. Allen and J. N. Baldwin, Department of Microbiology, University of Kentucky, Lexington.
3. Help! From the 7040—a statistical study of bacteriological data. M. Hotchkiss, O. F. Edwards and T. Redmon, Department of Microbiology, University of Kentucky, Lexington.
4. Biosynthetic control of isomaltase in *Saccharomyces cerevesiae.* J. W. Gorman, Department of Cell Biology, University of Kentucky, Lexington.
5. Transient "conventionalization" of gnotobiotic animals. R. F. Wiseman and H. A. Gordon, Departments of Microbiology and Pharmacology, University of Kentucky, Lexington.
6. Studies on the effectiveness of formalin inactivated West Nile virus vaccines. Diane Manker and Isaac Ruchman, Department of Microbiology, University of Kentucky, Lexington.
7. Inhibition of phospholipid synthesis in *Escherichia coli* by antibiotics. B. J. Bloomfield, Department of Agronomy, University of Kentucky, Lexington.

PHYSICS SECTION

Chemistry-Physics Building—Room 155

J. M. Pike, Chairman
Fletcher Gabbard, Secretary

10:00 A.M.

Invited Papers:

1. The Interdependence of Astronomy and Physics. W. S. Krogdahl, University of Kentucky. (30 minutes).
2. An Interdisciplinary Approach to Physics-Chemistry Teaching at the High-School Level. Harold Hanson, *Centre College* (20 minutes).

Intermission (15 minutes)
(Tea & Crumpets in Room 179)

Contribtued Papers:

1. Comments on the New Secondary School Curriculum. F. D. Boercker, *Georgetown College.*

* Speaker.

2. Half-Lives and Yields of X-Rays from Thermal Fission of U^{235} and Pu^{239}. L. Bridwell, *Murray State College.*
3. The Field Effect of Tellurium Films. Adil Shampoo and Manuel Schwartz, *University of Louisville.*
4. The Structure of Hard Anodic Films of Aluminum. Nicholas Mostovych, *University of Louisville.*
5. Beta Decay of S^{37}, Sudiman Wirjoamidjojo and Bernard D. Kern, *University of Kentucky.*

PSYCHOLOGY SECTION

10:00 to 11:00 a.m., Friday, November 12, Student Union Building, Room 234. Conversation Hour with Dr. B. F. Skinner.

9:00 a.m., Saturday. Sectional Meeting.

Agricultural Science Center—Room N-12

Earl A. Alluisi, Chairman
Mary Ellen Curtin, Secretary

1. "Verbal mediation in reverse association: the role of temporal factors," Richard A. Kulp, Humrro, Ft. Knox, Kentucky.
2. "The effect of stimulus range on the amount of information transmitted in absolute judgements of circular size," Patricia G. McGinty and Earl A. Alluisi, Psychology Department, University of Louisville.
3. "Transfer of inter-item associations from serial to paired—associate learning," Wayne L. Martin, Psychology Department, University of Kentucky.
4. "The effect of irrelevant information on absolute judgement at different levels of discrimination difficulty." Ben B. Morgan, Jr., Psychology Department, University of Louisville.
5. "Anonymous nuisance telephone calls to females," Frank Murray, Psychology Department, University of Kentucky.
6. "A comparison of learning curves in verbal and motor paired-associate tasks," Haywood S. Osborne, Jr., Psychology Department, University of Louisville.
7. "Fatigue as a subjective variable, or a scheme for relating three 'classical' measures of fatigue," Thomas J. Rebbin, Psychology Department, University of Louisville.
8. "Numerosity and the power function," Thomas J. Rebbin and Curtis L. Barrett, Psychology Department, University of Louisville.
9. "Gravity preference: discrimination between low levels of gravity by rats," W. Kirk Richardson and R. Chris Martin, Wenner Gren Laboratory, University of Kentucky.
10. "Interference effects and the retention of verbal material in process and reactive schizophrenia," Stanley Zupnick, Psychology Department, University of Louisville.

ZOOLOGY SECTION

Agricultural Science Center—Room N-10

H. E. Shadowen, Chairman

1. The Bats of Kentucky. Wayne H. Davis and Roger W. Barbour, Department of Zoology, University of Kentucky.

2. The Effects of Low Temperatures upon Chick Embryos Treamted *in ova*. Mary McGlasson, Department of Biology, Eastern Kentucky State College.
3. The Establishment of Animal-Vegetal Polarity in the Oocytes of the Gastropod, *Ilyanassa obsoleta*. Arthur L. Applegate, Department of Biology, Western Kentucky State College.
4. Notes on the Spawning Behavior of *Semotilus atromaculatus* (Mitchell). Morgan E. Sisk, Department of Biology, Murray State College.
5. The Fishes of West Kentucky. Part I. Survey of the Fishes in Clark's River. Morgan E. Sisk.
6. The Occurrence of the Brown Recluse Spider, *Loxosceles reclusa* Gertsch and Mulaik, in western Kentucky. Morgan E. Sisk.
7. The Effect of Colored Lights on Ingestion by the Immature Two-spotted Mite, *Tetranychus urticae*. T. N. Seay and J. G. Rodriguez, Department of Entomology and Botany, University of Kentucky.
8. Reaction of Various Species of Macrochelid Mites to Temperature and Humidity. Pritam Singh and J. G. Rodriguez, Department of Entomology and Botany, University of Kentucky.
9. Some Experimental Infections of *Paragonimus westermani* in Cats. J. M. Edney, Department of Zoology, University of Kentucky.
10. Multiple Genetic Perspectives of a Specific Locus in *Drosophila melanogaster*. Sara Frye.

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TRANSACTIONS OF THE ACADEMY OF SCIENCE

Volume 27 — 1966

Editorial Office

Department of Plant Pathology
University of Kentucky
Lexington, Kentucky

Published by

THE KENTUCKY ACADEMY OF SCIENCE

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TRANSACTIONS of the KENTUCKY ACADEMY of SCIENCE

Official Organ

KENTUCKY ACADEMY OF SCIENCE

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The Kentucky Academy of Science

Founded May 8, 1914

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RAYMOND E. HAMPTON, *Editor*
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THE OCCURENCE OF THE BROWN RECLUSE SPIDER (*Loxosceles reclusa* Gertsch and Mulaik) IN WESTERN KENTUCKY.

MORGAN E. SISK
Department of Biological Science
Murray State College, Murray, Kentucky

During the spring and summer of 1965 a number of bites, attributed to the Brown recluse spider (*Loxosceles reclusa* Gertsch and Mulaik), were treated by physicians in Murray, Kentucky. To my knowledge the presence of this species in Kentucky has previously not been reported in the zoological literature although it has been recorded from Missouri, Arkansas and Tennessee, all bordering parts of Kentucky.

The following extant specimens are therefore listed as records of the species in Kentucky. Specimens are from the collection of invertebrates at Murray State College, Murray, Kentucky.

Museum number

606–Ballard County, from a private dwelling in Wickliffe. 11:VI:1965.

607–Calloway County, from a farm out-building near Murray. 15:VII:1965.

608–Calloway County, from a farm house 1 mi. W. of Murray. 10:VIII:1965.

609–Calloway County, from Science Building, Murray State College. 13:VI:1965.

610–Calloway County, from private dwelling in Murray. 6:VIII:1965.

611–Calloway County, from private dwelling in Murray. 11:IX:1965.

612–Calloway County, from farm house 2.5 mi. E. Murray. 18:IX:1965.

613–Calloway County, from farm well-house 3 mi. S. Murray. 9:X:1965.

614–Calloway County, from farm well-house 3 mi. S. Murray. 9:X:1965.

615–Calloway County, from farm well-house 3 mi. S. Murray. 9:X:1965.

616–Calloway County, from farm well-house 3 mi. S. Murray. 9:X:1965.

617–Calloway County, from farm well-house 3 mi. S. Murray. 9:X:1965.

618–Calloway County, from farm well-house 3 mi. S. Murray. 9:X:1965.

619–Calloway County, from farm well-house 3 mi. S. Murray. 9:X:1965.

620–Calloway County, from farm well-house 3 mi. S. Murray. 9:X:1965.

623–Fulton County, from service station in Fulton. 7:VII:1965.

621–Graves County, 3 mi. E. Mayfield on hwy. 121, from old barn. 19:VII:1965.

622–Graves County, from upholstery shop in Farmington. 21:VIII:1965.

624–Marshall County, from farm dwelling E. of Benton. 14:VII:1965.

625—McCracken County, 3 mi. W. Paducah on hwy. 62, basement of private dwelling. 10:VI:1965.

626—McCracken County, 3 mi. W. Paducah on hwy. 62, old smokehouse. 10:VI:1965.

627—McCracken County, 3 mi. W. Paducah on hwy. 62, farm outbuilding. 10:VI:1965.

Although these records are scattered and few in number, there is little doubt that intensive collecting will confirm the presence of the species in the remaining two counties west of the Tennessee River as well as other areas of the state.

UNUSUAL SPAWNING BEHAVIOUR OF THE NORTHERN CREEK CHUB, *Semotilus atromaculatus* (Mitchill).

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While collecting fish near the headwaters of Clark's River, Calloway County, Kentucky, in the summer of 1965, an observation was made on unusual spawning behaviour of the Northern creek chub, *Semotilus astromaculatus* (Mitchill).

Spawning was observed on 11 June in a portion of the stream that consisted of small riffle-connected pools, many of which were less than two meters wide, 10 meters long and 20 centimeters deep. The water was clear, cool (63°F.) and flowed over coarse gravel barren of vegetation.

The initial observation was made on a group of fishes that seemed to have aggregated as a breeding colony below a moderately flowing riffle. The individuals congregated near the lower end of a small pool, then, en masse, swam rapidly to the head of the pool. Near the lower end of the riffle the fishes quickly turned as one body, sides flashing, and dispersed. Individuals and small groups returned to the lower end of the pool where they regathered and repeated the process. This methodical behaviour occured several times, the fishes seemingly oblivious of three observers who witnessed the activity from the head of the riffle. It became apparent that eggs were being shed near the lower end of the riffle, possibly when the fishes turned. Numerous darters (later identified as *Etheostoma rufilineatum* and *E. gracile*) had collected in this area and appeared to be searching for spawn. Some of the demersal eggs were recovered from the coarse gravel bottom below the riffle. There were no nests of any kind, an unusual character of this species' spawning habits.

The small size of the pool permitted collecting the entire breeding aggregation in one seine haul. The group consisted of 29 mature females, 16 mature males and nine immature (probably year-old) males. An interesting feature of the 16 breeding males was the lack of prominant nupital tubercles.

The spawning behaviour herein described is atypical of *S. atromaculatus.* It was not an isolated case however, for two similar aggregations were observed in the same area on the following day.

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Previous accounts of the species breeding activity refer to gravelly nest ridges (Hankinson, 1931), nest-pits (Miller, 1962) or similar bottom depressions into which eggs are deposited (Lagler et. al., 1962; Harlan and Speaker, 1956). Wth such documented evidence for nest building, the question arises, why were the fishes behaving so abnormally in spawning?

The answer may involve several factors. Photoperiodicity, temperature, current, turbidity and depth of water all play important roles in the cyclic reproductive process in fishes (Miller, 1962). At least three of these extrinsic factors may have produced the massed spawning observed in *S. atromaculatus.*

Creek chubs inhabit the gravel bottomed, riffled portions of high gradient streams in early spring where they normally build nests and spawn (Harlan and Speaker, 1956; Trautman, 1957). West Kentucky experienced an unusually cool and rainy spring in 1965 that extended into June. Creeks and headwaters of small rivers in the area that usually provided suitable nesting habitat for creek chubs were periodically flooded and remained turbid and cool through May. These adverse environmental conditions may have delayed breeding so far beyond the normal period that when favorable conditions did prevail the intrinsic urge to spawn overwhelmed the nest building ritual. This is pure speculation but the the best explanation that can be provided at present. Future plans concerning a detailed life history study of this species in Clark's River have been formulated and will entail careful observation of its breeding activity. This study may provide information that will account for the lack of nest building and mass spawning as described herein.

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EDIBLE WILD SPERMATOPHYTES OF CALLOWAY COUNTY, KENTUCKY

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Introduction

The following list of edible spermatophytes of Calloway County was compiled from three sources: the Murray State College Herbarium, literature records (Braun, 1943), and field observations. The writer(s) is aware that sight records are not valid for taxonomic consideration. However, as little collecting has been done in the county it was considered worthwhile to include them in order to make the list more complete. Sight records are included only for those plants which are easily identified and for which there was no doubt. Often plants are recognizable even though they are not in the proper stage for collection and use for herbarium specimens. The list includes all plants growing wild, though some may be escapes from cultivation.

The nomenclature and arrangement of species is that of Gray's manual (Fernald, 1950). The brief habitat descriptions are for the most part those of the same author. The scientific names and common names of the plants are given along with the edible parts. For additional information and methods of preparing for use as food, the reader is referred to Saunders (1920), Medsger (1939), Jaques (1943), Kephart (1945), and Gibbons (1962).

Annotated List of Species:

PINACEAE

Pinus strobus L. White Pine. Woods. Pitch.

TYPHACEAE

Typha latifolia L. Common Cattail. Marshes or shallow water. Rootstocks, stem, young fruiting spikes, pollen.

Typha angustifolia L. Cattail. Basic or alkaline water. Rootstocks, stem, young fruiting spikes, pollen.

Sagittaria latifolia Willd. Arrowhead; Duck Potatoes; Wapatoo. In water or wet places. Tubers.

ALISMATACEAE

Sagittaria latifolia Willd. Arrowhead; Duck Potatoes; Wapatoo. In water or wet places. Tubers.

GRAMINAE

Arundinaria gigantea (Walt.) Chapm. Giant Cane. River banks and swamps. Seeds, young shoots.

Oryzopsis hymenoides (R. and S.) Ricker. Indian Millet. Sandy prairies and rocky slopes. Seeds.

CYPERACEAE

Scirpus validus Vahl. Great Bulrush. Brackish or fresh shallow water and marshes. Roots, base of stem.

ARACEAE

Arisaema triphyllum (L.) Schott. Jack-in-the-Pulpit; Indian Turnip. Rich wet woods, swamps and peat bogs. Corm or bulb.

COMMELINACEAE

Commelina communis L. Common Dayflower. Meadows and disturbed soils. Used as potherb.

LILACEAE

Uvularia perfoliata L. Papillose Bellwort. Thin woods, thickets and clearings in acid soils. Young shoots, roots.

Allium cernuum Roth. Nodding Wild Onion. Ledges, gravels, rocky or wooded slopes. Bulb, leaves .

Allium canadense L. Wild Garlic. Low woods, thickets, and meadows. Top bulbs, underground bulbs.

Allium vineale L. Field Garlic. Grasslands and fallow fields. Bulbs, young tops.

Allium tricoccum Ait. Wild Leek; Ramp. Rich woods and bottoms. Bulbs, leaves.

Hemerocallis fulva L. Orange Day-Lily. Roadsides, borders of fields and thickets. Fresh blooms and buds, withered blossoms, tubers, sprouting stalks.

Lilium superbum L. Turk's Cap Lily. Peaty meadows, swales, wet sands and swampy woods. Bulbs.

Erythronium americanum Ker. Yellow Adder's Tongue. Rich woods, bottom lands and meadows. Bulb, leaves.

Ornithogalum umbellatum L. Star-of-Bethlehem. Roadsides, grasslands and thickets. Bulbs.

Yucca filamentosa L. Silkgrass. Dry sands, beaches, pine lands and old fields. Seed pods.

Asparagus officinalis L. Garden Asparagus. Sandy fields and roadsides. Young sprouts, seeds.

Smilacina racemose (L.) Desf. False Solomon's-seal. Woods, clearings, bluffs and uplands. Berries.

Polygonatum biflorum (Walt.) Ell. True Solomon's-seal. Dry to moist, sandy, loamy or rocky woods and thickets. Young plant, roots.

Smilax herbacea L. Carrion-flower. Rich or alluvial thickets, meadows and low woods. Berries.

Smilax bona-nox L. China Brier. Dry to moist dunes, clearings, fields and thickets. Tuberous roots.

JUGLANDACEAE

Juglans cineria L. Butternut. Rich woods and river terraces. Nut, sap.

Juglans nigra L. Black Walnut. Rich woods, Nut.

Carya illinoensis (Wang.) K. Koch. Pecan. Bottomlands. Nut.

Carya cordiformis (Wang.) K. Koch. Bitternut Hickory. Wet to dry woods, stream banks and swamps. Nut.

Carya ovata (Mill.) K. Koch. Shellbark Hickory. Rich woods, bottom and slopes. Nuts.

Carya tomemtosa Nutt. Mockernut . Dry to moist woodlands. Nuts.

Carya glabra (Mill.) Sweet. Pignut Hickory. Dry woods and slopes. Nuts.

CORYLACEAE

Corylus americana Walt. Hazelnut. Thickets. Nut.

Betula lenta L. Sweet Birch: Black Birch. Rich woods and uplands. Young twigs, bark, sap.

Betula lutea Michx. f. Yellow Birch. Rich woods. Bark.

FAGAGEAE

Fagus grandifolia Ehrh. Beech. Rich Uplands. Nut.

Castanea pumila (L.) Mill. Chinquapin. Dry woods and thickets. Nuts.

Quercus alba L. White Oak. Dry woods. Acorn.

Quercus bicolor Willd. Swamp White Oak. Bottomlands, stream borders and swamps. Acorns.

Quercus muhlenbergii Engelm. Chestnut Oak. Dry calcareous slopes and ridges or rich bottoms. Acorns.

Quercus prinus L. Chestnut Oak. Dry or rocky woods, bluffs and crests. Acorns.

ULMACEAE

Ulmus rubra Muhl. Red Elm; Slippery Elm. Rich soil. Inner bark.

Celtis occidentalis L. Hackberry. Dry to moist rich woods, river banks, rocky barrens and sand. Pulp of the fruit, berries.

MORACEAE

Morus rubra L. Red Mulberry. Rich woods. Berries.

Morus alba L. White Mulberry. An escape in various habitats. Berries.

URTICACEAE

Urtica dioica L. Stinging Nettle. Waste places, roadsides and old fields. Young shoots.

ARISTOLOCHIACEAE

Asarum canadense L. Wild Ginger. Rich woods and shaded calcareous ledges. Rootstock.

POLYGONACEAE

Rumex crispus L. Curley Dock. Cultivated and waste soils, old fields and roadsides. Leaves.

Rumex acetosella L. Sheep Sorrel. Worn-out fields and sour soils. Leaves, young shoots.

Polygonum persicaria L. Lady's Thumb; English Smartweed. Damp clearings, cultivated ground, roadsides, shores, etc. Use as a salad plant.

Polygonum cuspidatum Sieb. and Zucc. Japanese Knotweed. Waste places, neglected gardens and old fields. Young shoots, large young stalks.

CHENOPODIACEAE

Chenopodium album L. Lamb's Quarters; Goosefoot. Cultivated and waste ground. Young plants, seeds.

AMARANTHACEAE

Amaranthus hybridus L. Green Amaranth. Waste places, cultivated fields, etc. Seeds and leaves.

Amaranthus retroflexus L. Green Amaranth; Pigweed. Waste or cultivated grounds. Seeds and leaves.

Amaranthus graecizans L. Prostrate Amaranth. Disturbed or waste ground. Seeds.

PHYTOLACCACEAE

Phytolacca americana L. Pokeweed; Poke Salad. Rich low ground, recent clearings and roadsides. Young shoots, leaves.

PORTULACEAE

Portulaca oleracea L. Common Purslane. Cultivated and waste ground. Young stems, fleshy stems, leaves, flower buds, seeds.

Claytonia virginica L. Spring Beauty; Fairy spuds. Rich woods, thickets and clearing. Tuber.

CARYOPHYLLACEAE

Stellaria media (L.) Cyrill. Common Chickweed. Lawns, roadsides, etc. Potherb plant.

NYMPHAEACEAE

Nelumbo lutea (Willd.) Pers. Yellow Nelumbo; Chinquapin. Ponds, quiet streams and estuaries. Seed, tuber, entire plant.

BERBERIDACEAE

Podophyllum peltatum L. Mayapple. Rich woods, thickets and pastures. Fruit, root for medicinal purposes.

ANONACEAE

Asimina triloba (L.) Dunal. Pawpaw. Rich woods and alluvium. Fruit.

LAURACEAE

Sassafras albidum (Nutt.) Nees. Sassafras. Woods and thickets. Leaves, bark, roots, stems, winter buds.

Lindera benzoin (L.) Blume. Spicebush. Damp woods and brooksides. Bark, leaves, twigs.

CRUCIFERAE

Lepidium virginicum L. Peppergrass. Dry open soil, roadsides and waste places. Pods, leaves.

Capsella bursa-pastoris (L.) Medic. Shepherd's Purse. Roadsides, cultivated grounds and waste places. Potherb plant.

Brassica nigra (L.) Koch. Black Mustard. Waste places and cultivated fields. Young leaves, seeds, bloom buds, seeds.

Sisybrium officinale (L.) Scop. Hedge Mustard. Waste places. Seeds, leaves.

Rorippa islandica (Oeder) Borbas. Yellow Cress. Wet shores and damp openings. Roots, young leaves.

Barbarea vulgaris R. Br. Yellow Rocket; Bitter Cress. Meadows, brooksides and damp woods. Young leaves, bloom buds.

Barbarea verna (Mill.) Aschers, Early Wintercress. Fields and meadows. Young leaves, bloom buds.

Dentaria diphylla Michx. Two-leaved Toothwort. Damp, rich woods. Rootstocks.

Dentaria laciniata Muhl. Rich woods, bottoms and calcareous rocky banks. Rootstock.

Cardamine bulbosa (Schreb.) BSP. Spring-Cress. Springs, bottomland woods or meadows. Leaves.

Cardamine rotundifolia Michx. Mountain Water-Cress. Springy places and brooksides. Leaves.

HAMAMELIDACEAE

Liquidambar styraciflua L. Sweet Gum. Swampy woods. Sap.

ROSACEAE

Pyrus angustifolia Ait. Wild Crab Apple. Woods, bottoms and thickets. Fruits.

Pyrus coronaria L. Wild Crab Apple. Bottoms, wooded slopes, thickets and clearings. Fruits.

Amelanchier canadensis (L.) Medic. Service Berry; June Berry; Shad Bush. Swamps, low grounds and thickets. Berries.

Crataegus mollis (T. and G.) Scheele. Hawthorne. Open woods, usually in alluvial or fertile soil. Fruits.

Fragaria virginiana Duchesne. Strawberry. Fields, open slopes and borders or woods. Berries.

Rubus occidentalis L. Black Raspberry. Rich thickets, ravines and borders of woods. Fruit.

Rubus trivialis Michx. Dewberry. Low to dry grounds of Coastal Plain. Fruit.

Rubus allegheniensis Porter. Allegheny Blackberry. Dry clearings and thickets. Fruit.

Rubus frondosus Bigel. Common Blackberry. Thickets and borders of woods. Fruit.

Prunus americana Marsh. Wild Plum. Thickets, borders of woods, stream banks and fence rows. Fruit.

Prunus serotina Ehrh. Wild Black Cherry. Dry woods and fence rows. Fruit.

LEGUMINOSAE

Gymnocladus dioica (L.) K. Koch. Kentucky Coffee-tree. Rich woods. Seeds.

Gleditsia triacanthes L. Honey Locust. Rich woods. Pulp of seed pods.

Baptisia tinctoria (L.) R. Br. Yellow Wild Indigo. Dry open woods and clearings. Young shoots.

Trifolium pratense L. Red Clover. Roadsides, clearings and turf. Young leaves and stems.

Medicago lupulina L. Black Medic. Roadsides and waste places. Seeds.

Robinia pseudo-acacia L. Black Locust. Woods and thickets. Flowers, seeds, pods.

Wisteria macrostachya Nutt. Kentucky Wisteria. Swamps and rich woods. Flower clusters.

Vicia villosa Roth. Hairy Vetch. Roadsides and ditches. Seeds.

Apios americana Medic. Groundnut; Potato-bean; Indian Potato. Rich thickets. Tubers.

Phaseolus polystachios (L.) BSP. Wild Bean. Dry pine or oak woods and sandy thickets. Seeds

OXALIDACEAE

Oxalis violacea L. Violet Wood-sorrel. Woods, shaded slopes, gravelly banks and prairies. Leaves.

Oxalis stricta L. True Wood-sorrel. Dry open soil. Leaves.

ANACARDIACEAE

Rhus typhina L. Staghorn Sumac. Dry, rocky or gravelly soil. Berries.

Rhus glabra L. Smooth Sumac. Dry soil. Berries.

Rhus copallina L. Dwarf Sumac. Dry woods and openings. Berries.

AQUIFOLIACEAE

Ilex vomitoria Ait. Cassina; Yaupon. Sandy woods and clearings Leaves.

Ilex verticillata (L.) Gray. Winterberry. Swamps, pond margins, and damp thickets. Leaves.

ACERACEAE

Acer saccharum Marsh. Sugar Maple. Rich, mostly hilly woods. Sap.

Acer nigrum Michx. f. Black Maple. Rich calcareous or alluvial woods. Sap.

Acer rubrum L. Red Maple. Swamps or uplands. Sap.

Acer saccharinum L. Silver Maple. Riverbanks and bottomlands. Sap.

Acer negundo L. Boxelder; Ash-leaf Maple. River banks, streams, lake shores and lowlands. Sap.

BALSAMINACEAE

Impatients capensis Meerb. Spotted Touch-me-not. Wet, acid to subacid swamps. Young stems.

RHAMNACEAE

Ceanothus americanus L. New Jersey Tea. Dry open woods and gravelly banks. Leaves.

VITACEAE

Vitis labrusca L. Fox Grape. Wet or dry thickets, border of woods to uplands. Fruit.

Vitis aestivalis Michx. Summer Grape. Dry woods and thickets. Fruit.

Vitis cinerea Engelm. Sweet Winter Grape. Rich, low thickets, bottoms and banks of streams. Fruit.

Vitis vulpina L. Frost Grape. Riverbanks, bottom lands and rich thickets. Fruit.

Vitis rotundifolia Michx. Musadine. Woods, thickets, sandhills and shores. Fruit.

VIOLACEAE

Viola palmata L. Early Blue Violet; Johnny-Jump-Up. Rich deciduous woods and shady calcareous ledges. Leaves and stems.

PASSIFLORACEAE

Passiflora lutea L. Yellow Passion-flower. Thickets and borders of woods. Fruit.

Passiflora incarnata L. Passion-flower; Maypop. Sandy thickets and open soils. Fruit.

CACTACEAE

Opuntia humifusa Raf. Prickly Pear. Dry sands and rocks. Fruit pulp, stems.

NYSSACEAE

Nyssa aquatica L. Cotton Gum; Tupelo. Inundated swamps and wet woods. Fruit.

Nyssa sylvatica Marsh. Black Gum; Sourgum; Tupelo. Low acid woods, swamps and shores. Fruits.

MELASTOMACEAE

Rhexia Virginica L. Meadowbeauty. Peats, wet sands and gravels. Leaves.

ONAGRACEAE

Oenothera biennis L. Evening Primrose. Dry open soils. Roots, young shoots.

UMBELLIFERAE

Osmorhiza longistylis (Torr.) DC. Sweet Anise. Rich, often alluvial woods and thickets. Root.

ERICACEAE

Gaylussacia frondosa (L.) T. and G. Dangleberry. Dry woods and clearings. Fruit.

Galyussacia baccata (Wang.) K. Koch. Huckleberry. Dry or moit woods, thickets and clearings. Fruit.

Vaccinium stamineum L. Deerberry; Squaw Huckleberry. Dry woods, thickets and clearings. Fruit.

Vaccinium vacillans Torr. Early Sweet Blueberry; Sugar Huckleberry. Dry open woods, thickets and clearings. Fruit.

Vaccinium angustifolium Ait. Low Sweet Blueberry. Dry open barrens, bogs and rocks. Fruit.

Vaccinium corymbosum L. Highbush-Blueberry. Swamps, low woods or dry uplands. Fruit.

EBENACEAE

Diospyros virginiana L. Persimmon. Dry woods, old fields and clearings. Fruit.

ASCLEPIADACEAE

Asclepias tuberosa L. Butterfly-weed; Orange Milkweed. Dry, open soil. Pods and stems.

Asclepias syriaca L. Common Milkweed. Thickets, roadsides, dry fields, etc. Early sprouts, tops, flowers, young pods.

CONVOLVULACEAE

Ipomoea pandurata (L.) G. F. W. Mey. Wild Potato-Vine. Dry open or partly shaded soil. Roots.

LABIATAE

Marrubium vulgare L. Horehound. Waste places. Leaves.

Glechoma hederacea L. Ground-Ivy. Roadsides, yards and damp shady places. Leaves.

Monarda didyma L. Oswego Tea. Rich woods, thickets and bottom lands. Leaves.

Monarda fistulosa L. Wild Bergamot. Dry thickets, clearings and borders of woods. Leaves.

Mentha longifolia (L.) Huds. Horse Mint. Thickets, roadsides and damp shores. Leaves.

Mentha spicata L. Spearmint. Wet places near settlements. Sprigs.

Mentha piperita L. Peppermint. Brooksides, wet meadows, etc. Leaves.

Mentha arvensis L. Field Mint. Damp open soils and shores. Leaves.

SOLANACEAE

Physalis pubescens L. Ground-Cherry; Strawberry Tomato. Damp to dry open woods, clearings, sand dunes and disturbed soils. Fruits.

Physalis missouriensis Mackenz. and Bush. Strawberry Tomato. Rocky open woods and barrens to cultivated and waste places. Fruit.

Physalis angulata L. Ground-Cherry. Borders or woods and thickets or waste grounds. Fruit.

Physalis subglabrata Mackenz. and Bush. Ground-Cherry. Shores, meadows, fields, roadsides and waste places. Fruit.

Physalis heterophylla Nees. Ground-Cherry. Dry open woods and clearings. Fruit.

SCROPHULARIACEAE

Verbascum thapsus L. Common Mullein. Fields, rocky or gravelly banks, etc. Leaves.

Veronica americana (Raf.) Schwein. American Brooklime. Shallow water, spring heads, rills and swamps. Leaves, stems .

PLANTAGINACEAE

Plantago major L. Common Plantain. River gravels, damp ledges, etc. Leaves.

RUBIACEAE

Mitchella repens L. Partridge Berry. Dry or moist knolls in woods. Berries.

CAPRIFOLIACEAE

Viburnum cassinoides L. Withe-Rod. Thickets, clearings, swamps and borders of woods. Fruits, leaves.

Viburnum prunifolium L. Black-haw. Thickets, borders of woods, shores, etc. Fruit.

Sambucus canadensis L. Elderberry. Wet, damp or rich soils. Fruit, fresh flowers.

VALERIANCEAE

Valerianella chenopodifolia (Pursh) DC. Corn Salad. Meadows, bottoms and fields. Young leaves.

Valerianella intermedia Dyal. Corn Salad. Banks of streams, meadows and damp fields. Leaves.

COMPOSITAE

Silphium laciniatum L. Compass-plant. Prairies and meadows. Upper parts of stem.

Helianthus annuus L. Common Sunflower. Plains, bottoms, waste places, etc. Seeds.

Helianthus laetiflorus Showy Sunflower. Open woods and thickets. Tubers.

Helianthus tuberosus L. Jerusalem Artichoke. Rich or damp thickets. Tubers.

Arctium lappa L. Great Burdock. Waste places, roadsides, chiefly in calcareous soils. Leafstalks, young flower-stalks, root.

Arctium minus (Hill) Bernh. Common Burdock. Waste land. Leafstalks, roots, young flower stalks.

Cichorium intybus L. Chicory; Blue Sailors. Fields and roadsides. Young leaves, roots.

Taraxacum officinale Weber. Common Dandelion. Lawns, roadsides, grasslands and open grounds. Leaves, roots.

Lactuca scariola L. Prickly Lettuce. Roadsides and waste grounds. Young plant, young leaves.

Lactuca canadensis L. Wild Lettuce; Horseweed. Thickets, borders of woods and clearings. Leaves and stems.

Summary:

The preceding list includes 166 species. These are distributed in 106 genera, belonging to 55 families.

Since there are no adequate lists either of plants of Calloway County or of all edible plants, it follows that the present list is an incomplete one. There are no doubt other plants occurring in the county which are edible and are not found on this list. This is due to two reasons: (1) the plant was not observed or found in the literature, (2) the plant could not be found on the lists of edible plants available to the writer. Future work may add other species to the present list.

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POLLEN LONGEVITY STUDIES IN *Hevea brasiliensis**

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Successful pollen storage is important in *Hevea* plant breeding to facilitate the crossing of clones on an unfavorable day, especially on a rainy or cloudy day when dehiscence of anthers is doubtful and percentage of pollen germination is poor (Majumdar 1966). A considerable time can be saved by storing pollen in a 'pollen bank' to use as needed. The maintenance of the viability of pollen is also valuable especially if pollen grains are to be obtained from another locality. For these reasons this investigation was undertaken.

A series of temperatures from 0°C to 50°C were used for the experiment and relative humidities were recorded for each temperature. Fresh flowers with anthers were kept in suitable containers and stored at different temperatures. Germination tests were made in 15% sucrose plus .01% boric acid solution, using the hanging drop method (Majumdar 1964). Viability was determined daily. For each sample 4 slides were cultured. Germination counts were made at random in 10 low power microscope fields, each containing from 15 to 20 pollen grains. The results of table I are the average percentage of pollen germination after 6 hours of sowing at 25°C.

The interesting result is that all the clones have shown the greatest longevity at temperatures of 0°, 5° and 10° centigrade and at a humidity of 75-81%. It is seen from the table that *Hevea brasiliensis* pollen retains its viability up to 17 days but that the percentage of viable pollen is very negligible after 10 days of storage. If it is presumed that pollen with a viability of 10% or higher may result in the production of fruits, then, *Hevea brasiliensis* pollen can be used for pollination up to 10 days after storing at the temperatures of 0 to 10°C and at a relative humidity of 75-81%.

Flowers stored at a temperature of 24°-25°C with a relative humidity of 72% yielded 52.3% pollen germination on the first day, 34% on the second day, 21% on the third day, 8.3% on the fourth day, 3% on the fifth day and none or only 1.3% germination on the sixth day.

In other experiments flowers were placed inside an oven and subjected to a series of temperatures from 30° to 40°C. Pollen germina-

* This work had been carried out at the Rubber Research Institute of Malaya, Kuala Lumpur, Malaysia.

TABLE 1.—THE LONGEVITY OF POLLEN AT VARIOUS STORAGE TREATMENTS

Clones		Temperature in °C	Before Storage	Average germination % After Storage (days) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
RRIM 604	*	5°C	65	59	53	45	44	31	23	22	13	11	9	9	5	3	3	....		
RRIM 516		5°C	80	72	57	51	38	28	18	8	8	8	8	8	2	2	1	1	1	....
PR 107		5°C	61	62	52	43	38	37	31	28	25	22	22	16	11	8	8	6	5	2
	Mean		68.6	64.3	54	46.3	40	32	24	22.6	18.6	13.6	13	11	6	4.3	4	2.3	2	.66
RRIM 604		10°C	68	60	52	47	41	29	27	25	20	18	11	11	4	4	2	....	....	
RRIM 516		10°C	71	59	47	38	32	22	19	15	15	12	11	9	9	8	6	4	....	
PR 107		10°C	75	68	51	44	39	32	23	16	15	14	14	6	5	5	2	2	....	
	Mean		71.3	62.3	50	43	37.3	27.6	23	18.6	16.6	16	12	8.6	6	5.6	3.3	2	....	
RRIM 604		24-25°C	69	56	39	21	7	1	....	....										
RRIM 516		24-25°C	62	52	27	19	9	5	1	....										
PR 107		24-25°C	65	49	36	23	9	3	3	....										
	Mean		65.3	52.3	34	21	8.3	3	1.3	....										
RRIM 604		30°C	81	51	18	8	4	....												
RRIM 516		30°C	67	42	22	7	....	....												
PR 107		30°C	69	47	16	11	5	....												
	Mean		72.3	46.3	18.6	8.6	3	....												
RRIM 604		35°C	68	34	13	....	....													
RRIM 516		35°C	65	37	11	....	....													
PR 107		35°C	73	29	19	3	....													
	Mean		68.6	33.3	14.3	1	....													
RRIM 604		40°C	75	18	....	....														
RRIM 516		40°C	60	21	....	....														
PR 107		40°C	64	13	3	....														
	Mean		66.3	17.3	1	....														

* As the longevity of pollen at 0°C and 5°C is more or less same, the results of storage treatment at 0°C were not included in the table.

tion occurred up to four days at 30°C, but at 35°C the pollen grains do not survive more than two days. Few pollen grains germinated after 24 hours of storage of flowers at 40°C. Flowers when exposed to direct sunlight for 3-4 hours at temperatures of 32-37° and humidity of 48-50% suffered in viability and showed more bursting of pollen tubes.

A priliminary trial of artificial self-pollinations with pollen stored for 7-9 days at 0-10°C was successfully made for the clone RRIM 501. However, to confirm this result, further pollination experiments with stored pollen are needed.

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SOME SOURCES OF CERAMIC MATERIALS IN KENTUCKY

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Introduction

Geological investigations made since 1951 by the Kentucky Geological Survey have disclosed large reserves of materials which have many potential uses in the ceramic industry.

According to Webster's New International Dictionary, Second Edition, 1954, *ceramic* is defined as ". . . . relating to the art of making earthware, or, more broadly, the manufacture of any or all products made from earth by the agency of fire. . . ." This would include pottery, chinaware, brick, tile, heat-resisting refractory materials, cements, enamtls, glass, and many others. Some of the natural materials which are used in the manufacture of these ceramic products are clay, shale, feldspar, limestone, dolomite, and silica sand. The present discussion will deal primarily with the clay and shale resources of Kentucky. While such materials are prosaic to many geologists, they do, nevertheless, play important roles in one's daily affairs.

Clay and Shale Resources

Kentucky is a state rich in a variety of clay and shale deposits; they include the super heat duty refractory clays of the Olive Hill region of eastern Kentucky, the ball (chinaware) clays of Graves and adjacent counties in the Jackson Purchase region, absorbent (fuller's earth) clay near the outer edge of the Mississippi Embayment, underclays associated with coal seams of both eastern and western Kentucky, shale formations in the Paleozoic rocks, ranging in age from Silurian to Pennsylvanian, alluvial clays of the Ohio River Valley and other streams of the state including the high-level deposits along the ancient routes of the Kentucky and Licking Rivers, eolian deposits of the Ohio and Mississippi Valleys, residual clays of various limestone formations, and the little-known endellite or halloysite clays occurring in isolated deposits at major unconformities in Paleozoic rocks. The 1959 production of more than 984,000 tons of all types of clays and shales established a record high for Kentucky; the raw clays and shales were valued at $3,595,000 (U. S. Bureau of Mines, Minerals Yearbook).

In 1962 there were sixteen structural clay products plants, thirteen potteries, and seven refractory plants.

The high-grade chinaware and pottery clays of the Mississippi Embayment region of Kentucky are well known and constitute a valuable mineral resource. Various grades of ceramic and fire clays are mined there; these include ball, sagger, wad, fire, enamel and filler clays. Kentucky ranks second in the nation in ball clay production. Ball clay mining is centered around Hickory, Mayfield, and Pryorsburg in Graves County where lenticular clay deposits of high quality occur in unconsolidated sediments of Eocene age. Kentucky-Tennessee Clay Company's mine near Pryorsburg is the largest in the area. Pits producing clays for local potteries are more wide spread in the Jackson Purchase and may be found in several counties. Field and laboratory investigations have also disclosed some undeveloped deposits which have potential use in the structural clay products industry as decorative brick and tile.

Another clay of Kentucky's Mississippi Embayment region having potential commercial use is the Porters Creek Clay, a fuller's earth-type clay. The Porters Creek in Kentucky is exposed in an arcuate belt to the west and south of Kentucky Lake and the Tennessee River, extending from southeast of Murray northwestward to Paducah and then westward to Ballard County. Its high absorptive power makes it potentially commercial for filtering and decoloring oils, fats, and greases; for floor sweep and miscellaneous absorbent uses; rotary drilling mud; and the manufacture of insecticides. Tests of samples of Porters Creek Clay taken at widely separated points along the outcrop in Calloway, Marshall, Graves, and McCracken Counties indicate a large reserve of fuller's earth-type clay with oil absorbent properties better than the chemical oil standard (Oil Chemists Society).

Many shales and clays (including underclays) of Pennsylvanian age, in both the Eastern Interior Basin and Appalachian Plateau areas of Kentucky, are suitable for brick, tile, sewer pipe, flue linings, stoneware, and refractories. The Olive Hill flint clay bed, which occurs in the lower part of the Lee Formation, is the principal source of the raw material in the fire brick industry of northeastern Kentucky. Flint clay for the fire brick industry is recovered by strip mining methods in Carter, Greenup, and Rowan Counties. Many of these mines are small and scattered, operating intermittently depending on the demand. Exploration for reserves of flint clay, a refractory clay which can withstand extremely high temperatures, has extended southward into northwestern Morgan County. The Olive Hill district of northeastern Kentucky has been one of the major producers of refractory brick in the United States; the finished brick is shipped to steel producing centers for lining furnaces. Scattered plants in other parts of the two Kentucky coal fields produce quality brick, tile, sewer pipe and flue linings. Investigations by the Kentucky Geological Survey have pointed out undeveloped deposits which could be used in the manufacture of decorative brick, stoneware, and allied products.

One of the significant developments in the clay industry in Kentucky in recent years is the opening of several pits recovering clays and shales of Tradewater age (Pennsylvanian) in and adjacent to abandoned coal stripping operations near Lewisport, Hancock County, for use in structural clay products such as brick, tile, and sewer pipe. As many as seven plants in northwestern Kentucky and adjacent portions of Indiana have obtained part or all of their raw materials from this source; at the present time five plants representing four companies have active mining operations there. The discovery of these deposits was the leading factor in the construction of the new Murray Tile Company (now American Olean Tile Company) plant at Lewisport.

A number of Mississippian shales are suitable for brick, tile, and other heavy clay products. Some of these deposits are extensive, but since the presence of deleterious materials such as gypsum, dolomite, and limestone may occur from place to place, each deposit must be appraised individually. The Lower Mississippian New Providence and Rosewood shales are being used in Kentucky for the manufacture of brick and drain tile. Shale associated with the Hardinsburg Formation (Chesterian) was used for many years in the Cloverport area for the manufacture of floor and roof tile. There are undeveloped deposits of Mississippian shales in eastern, central, and western Kentucky which would be suitable for the manufacture of structural clay products if adequate markets could be established.

Silurian shales (Estill Formation) along the eastern rim of the Outer Bluegrass region show little possibility for structural clay products; further sampling and testing may be required. The presence of calcium carbonate causes abrupt overfiring and bloating at relatively low temperatures; in addition, the firing ranges are short.

Alluvial clays also have been used for the manufacture of pottery and structural clay products; they are currently being used in the manufacture of Portland cement, brick, drain tile, and pottery. Eolian deposits (loess) have been used for brick manufacture but are not known to be used currently in our state.

Residual clays (clays resulting from the decomposition of other sedimentary materials) have been used in Kentucky for the manufacture of brick. Plants near Hopkinsville, Lexington, and Louisville used such materials for a number of years.

Firing tests conducted cooperatively by the Kentucky Geological Survey and the U. S. Bureau of Mines indicate that some of the shales of Mississippian and Pennsylvanian ages which might be used in the manufacture of brick, tile, sewer pipe, and other structural clay products possess bloating characteristics which meet specification for production of expanded shale aggregate—an important ingredient in lightweight concrete production. These are common shales with fusibility ranging from 1850°F to about 2400°F, which expand satisfactorily on heating. In this testing program, 28 of 52 samples from 37 Kentucky counties fired lighter than 62.5 pounds per cubic foot at 2200°F. Advantages of this type of aggregate include good thermal insulating properties, high sound absorption, easier handling because of light weight, less dead load on structures, less reinforcing and structural steel required, and its presence in areas where conventional heavy aggregates are lacking. The lightweight aggregate industry is one of the most rapidly growing industries in the nonmetallic mineral field in the United States.

Kenlite Division of Ohio River Sand Company, Louisville, was the first (and only to date) plant to produce expanded shale aggregate in Kentucky. Production began in 1953 using a single rotary kiln; since that time two additional rotary kilns have been added to meet the increased demand. The plant, located in northern Bullitt County, uses New Providence Shale which is mined by conventional open-pit techniques. The finished product is a bloated or expanded shale, reddish-brown in color, which has been used for lightweight blocks, floor-fill concrete, tilt-up panels, and other purposes.

Of academic, if not economic interest, are the comparatively little known clays referred to variously as endellite, halloysite, metahalloysite, and allophane. In Kentucky these clays are found at or near the erosional unconformity between basal Pennsylvanian conglomeratic sandstones and underlying carbonate rocks of Mississippian age and near the erosional unconformity beneath the New Albany (Chattanooga) Shale and carbonate rocks of Silurian age. In addition to their possible use as catalysts in oil cracking, the high deformation temperatures of these clays suggest their possible use for super-duty refractories. Beneficiation and treatment of the clays before marketing are probably requisite; air or water separation methods would remove iron oxide and other impurities, and calcining would be desirable to reduce the shrinkage of the raw material.

Conclusions

The work of the Kentucky Geological Survey in the ceramic resources field may be summarized briefly by pointing out that the investigations to date indicate adequate clay and shale reserves for the existing ceramic industries in Kentucky and suggest undeveloped deposits of such quantity and quality as to support their expansion as well as additional clay-products industries.

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SOME EFFECTS OF STIRRING RATE ON DIFFUSION CELL CALIBRATION

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Introduction

The technique of measuring diffusion coefficients in liquids by means of diaphragm cells has been discussed in a classic paper by Gordon (3). This technique is one which gives relative values of the diffusion coefficient and it is therefore necessary to calibrate the units. Basically these cells consist of two compartments separated by porous diaphragms. The diffusion equations used are based upon the assumption that a quasi-steady state exists and result in

$$\ln \frac{\Delta C\phi}{\Delta C_o} = \beta D \Phi \qquad (1)$$

where $\Delta C\phi$ = concentration difference between the 2 compartments at time ϕ.

ΔC_o = concentration difference between the 2 compartments at time zero.

D = diffusion coefficient.

ϕ = time.

β = diffusion cell constant (related to compartment volumes, area of diaphragm pores and the pore lengths).

Derivation of this equation and discussion of the terms are given by Gordon (3) and Jost (4) among others. All of the terms involved in β cannot be measured directly and hence this term is usually arrived at by calibration with a solution of known diffusion coefficient such as KC1. Inherent in the use of equation (1) is the assumption of uniform but different concentrations in the two compartments which are separated by the diaphragm. Uniformity is usually attempted by means of mechanical stirring or agitation. It is this particular problem which is the concern of this paper. Other phenomena which may affect calibration results are discussed by Doshi (2), Spence (9), and Williams (11).

Originally these cells were used with the diaphragm in the horizontal position and stirring or agitation resulted from density differences, which left the possibility of non-reproducible stagnant layers adjacent to the interface. Mechanical agitation did indeed indicate different values of β for a given cell. Techniques involved were such as to cause mechanical erosion of the diaphragm surface. For more details on these experiments the reader is again referred to (3).

The stirring technique generally used with *vertical*-diaphragm cells was introduced by Pin Chang (1). Mechanically the stirrers can be placed anywhere such that no erosion of the diaphragm is necessary. The magnetic stirring principle was used by placing 2 iron bars, encapsulated in suitable material, one in each compartment and rotating them by magnets. The influence of stirring depends on the size and type of the diffusion cell and stirring mechanism. Strokes (10) used a stirring rate of 50 rpm (a rate of 20 rpm was necessary before stagant layers were removed). Lewis (5) found a critical rate of 80 rpm while Smith & Storrow (8) reported a critical value of 2 rpm. Implied in these results is that above a certain critical rpm the cell constant β should be of constant value and be representative of the molecular diffusion process through the diaphragm. That the problem is not this simple can be shown by data from the programs described in (2), (6), (9), (11) and subsequent data (7).

Qualitatively it appears that there should be some low critical stirring rate below which stagnant layers adjacent to the diaphragm have an influence which results in a value of β that is too low. However at high stirring rates "pumping" of the liquid or bulk transport through the diaphragm may occur and if this excess transport is ascribed to diffusion the resulting β will be too large. Presumably then there may be a region of constant β which lies above the lower value of stirring rate and whose upper limit must also be located. Some previous investigators have not concerned themselves with this upper limit and this may be a cause of some inaccuracy in their data.

Results

Work reported in references (2) and (9) employed stirring from flattened bottoms of the horizontal compartments (diaphragm vertical). At constant stirring rate Spence (9) showed a significant effect of stirrer position as measured from the diaphragm. A minimum value of β was found which occurred approximately at the central position of the compartment. Several cells with diaphragms of same specification and thickness (Corning F, 4-5.5 microns) showed considerable deviation from each other, however a minimum value for β occurred with the stirrer in the central position in each case. The fact that diaphragms of similar specification give vastly different diffusion results has been noticed and commented upon by many investigators. Variation in stirrer position was made in only one compartment. Williams (11) using end stirring (i.e., stirrers placed on the end of the compartments facing the diaphragm) purposely set the bars off center in opposite directions and noticed an increase of approximately 10% in β, thus indicating "mismatching" of fluid and pressure gradients influence the constant β. The deviations noticed by Spence may have been caused by similar effects.

Lu (6) found using the end stirring technique that the length of the stirring bar had the pronounced effect on β at constant rpm (100) as indicated in Table 1.

TABLE 1

Effect of Stirrer Bar Length on Cell Constant

Stirrer Bar Length	Cell Constant
⅞"	0.0890
⅞"	0.0915
1"	0.0990
1"	0.0987
1½"	0.1940
1½"	0.1810

One of the most comprehensive studies of the effects of stirring was made by Williams (11) using end stirring. At a temperature of 25°C the stirring rate in each compartment was varied simultaneously. Rates investigated were from 0 to 250 rpm and also intermittently at 100 rpm. The results are indicated in Fig. 1 for a particular cell.

As previously postulated a "plateau" region was found approximately at $60 < \text{rpm} < 110$. The value of β in this region was approximately 0.072 while intermittent stirring of 2 minutes duration every 30 minutes gave a value of approximately 0.071. The effect of temperature at constant stirring rate was also investigated. It was shown that as temperature was reduced in the range of 25°C to 4°C at a constant stirring rate of 100, β increased. Besides the obvious change in the diffusion coefficient of KCI this decrease in temperature caused a significant variation in the viscosity of the solutions with but a minor change in density. The use of intermittent stirring almost completely eliminated the effect of temperature (viscosity?). It was concluded from this work that bulk transport through the diaphragm is the principal reason for calibration variations. (See reference 11 for further discussion of this point.).

Doshi (2) using bottom stirring reports variations somewhat similar to Figure 1. Using the *same* cell and conditions but with end

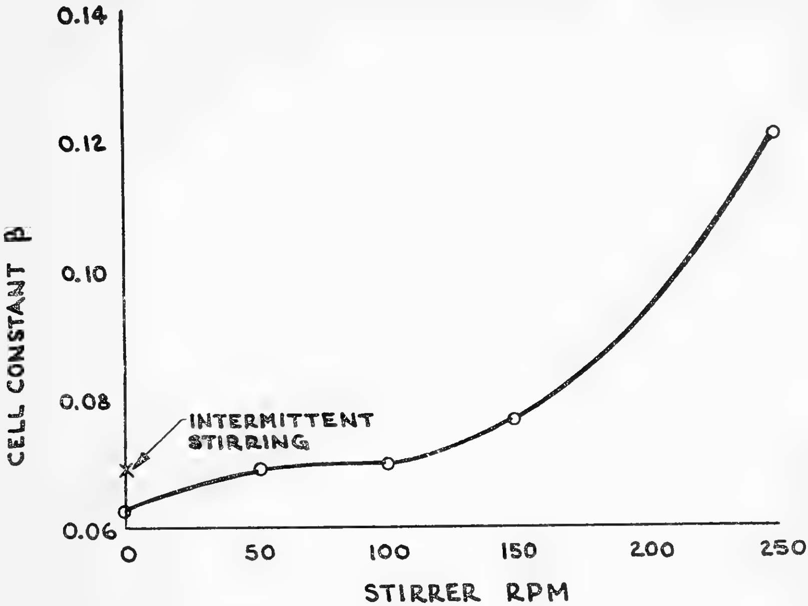

Fig. 1.

stirring (11) the following comparison of Table 2 is made. The value of rpm has no particular meaning in the comparison only the relative values of β and their variation.

In comparisons made between references (2, 6, 7, 9, 11) all conditions were the same except for bottom and end stirring.

TABLE 2
Effect of Stirring Position on Cell Constant

Stirrer Speed rpm	Cell Constant *Bottom Stirring* (3)	Cell Constant *End Stirring* (11)
50	0.0257	
80		0.0223
100	0.0265	
120		0.0253
200	0.0293	0.0262

Conclusions

It has been shown that the effect of mechanical stirring on the calibration of diaphragm cells is very important. Contrary to previous postulates that the cell constant approaches a constant value with increased stirring rate it was found that there exists a limited region of stirring rate for each cell. A minimum rate exists below which stagnant surface layers seriously affect the calibration and a miximum rate exists above which other problems (presumably bulk transport) become serious. Comparable values of the cell constant can be obtained by two different stirrer geometries and the use of intermittent stirring has been shown to be advantageous.

Acknowledgments

The author wishes to acknowledge the various students, cited below, who have worked both directly and indirectly with him on this subject. He also expresses appreciation to Dr. F. P. Pike for his cooperation and invaluable discussions.

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A TERNARY VAPOR-LIQUID EQUILIBRIUM SYSTEM METHANOL-BENZENE-TOLUENE

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Abstract

Experimental vapor-liquid equilibrium data are presented for the methanol-benezene-toluene system, and show a trough in the vaporus curve between the methanol-toluene and methanol-benzene azeotropes. Typical isothermal-isobaric diagrams are presented for the system, and a mechanism is described for facilitating the experimental investigations of ternary systems.

Introduction

The successful application of distillation techniques for separating mutually soluble liquids depends upon the availability of accurate vapor-liquid equilibrium data. These data are readily available for many binary systems, or may be satisfactorily approximted by standard methods which are both reasonably quick and accurate. On the other hand, ternary solutions, adding another degree of freedom to the system, create a considerably different picture (4). The available data are few, and the approximation methods are both difficult and frequently inaccurate. Likewise, because of the nature of the physical systems, experimental isobaric determinations at preselected values of equilibrium temperature, or concentrations in either liquid or vapor states are almost impossible. This situation presents the usual problem of three dimensional interpolation for correlations after data are obtained.

This paper presents (a) experimental data for hte vapor-liquid isobaric equilibrium on the methanol-benezene-toluene system (previously unpublished), (b) an easy, accurate, and dependable method of correlating the normal random data for a ternary system and (c) a system and classroom teaching aid for the elucidation of ternary equilibria in the area of a two binary azeotrope, ternary solution.

Experimental Procedure

The methanol, benezene, and toluene used in this investigation were of analytical reagent grade, and the proper boiling points were obtained for each component when checked in a boiling point apparatus of the Cottrell type.

The ternary vapor-liquid equilibrium samples and temperatures were obtained in a Altsheler still (1), with the temperature being measured by a No. 28 B and S guage copper-constantan theromcouple located approximately one inch above the Cottrell pump (2). The emf of the thermocouple was obtained with a Leeds and Northrup potentiometer to the accuracy of ± .03 mv., or approximately ± 0.5°C. The pressure was maintained at 760 mm of Hg (± 1 mm) by a No. 6 Cartesian manostat.

The still was initially charged with 300 cc of a ternary mixture and operated for at least four hours to insure the attainment of equilibrium, as judged by a constant boiling temperature. Upon completion of a run, samples of the liquid and vapor phases were obtained and quickly cooled to reduce vaporization losses.

Vapor-phase chromatographic techniques were employed for analyzing the equilibrium samples, using a Podbielniak Chromacon Series 9475A No. 274. The weight composition of each sample was obtained by an integration of the peaks from the recorder output. At least two analyses were made of each sample to minimize the analytical error.

Results

A summary of the vapor-liquid equilibrium data for the system methanol-benezene-toluene is presented in Table I. These data are best represented, however, by a three-dimensional, isobaric model (Figure 1). When the data are presented in this manner, temperature is the axis perpendicular to the basal equilateral triangular composition plane. A convenient base temperature and scale are selected for the temperature axis. For this particular system a base of 40°C and a scale of 1 cm equals 2°C were selected. At the apexes of the vapor and liquid composition triangles, rods of length commensurate with the boiling points of the pure components are inserted. Attached to these rods and directly above the sides of the triangles are the corresponding binary curves shaped according to data from the literature. This construction is shown in Figure 2.

Upon obtaining an experimental point, a rod whose length is proportional to the measured boiling point, is inserted in the base at the appropriate liquid or vapor composition. This procedure is then repeated for each experimental point. Figure 2 demonstrates this technique.

The top of each rod represents a particular point on the liquidus or vaporus surface, depending on the data considered. After a sufficient number of experimental points is obtained, the upper ends of the rods approximately define the liquidus and vaporous surfaces. It is

TABLE I.—RESULTS OF METHANOL-BENZENE-TOLUENE EQUILIBRIUM DISTILLATIONS

Run	Temp.	Mole Fraction in Liquid			Mole Fraction in Vapor		
No.	(°C)	Methanol	Benzene	Toluene	Methanol	Benzene	Toluene
1	104.0	0.000	0.144	0.856	0.000	0.287	0.713
2	72.0	0.020	0.980	0.000	0.234	0.766	0.000
3	85.0	0.028	0.141	0.831	0.414	0.180	0.406
4	59.5	0.279	0.475	0.246	0.621	0.323	0.056
5	96.0	0.006	0.165	0.829	0.134	0.286	0.580
6	74.5	0.031	0.518	0.451	0.414	0.442	0.144
7	96.0	0.006	0.166	0.828	0.130	0.288	0.582
8	84.0	0.033	0.069	0.898	0.518	0.075	0.407
9	82.5	0.007	0.706	0.287	0.075	0.820	0.105
10	87.5	0.006	0.423	0.571	0.131	0.569	0.300
11	65.0	0.185	0.066	0.749	0.779	0.048	0.173
12	62.5	0.537	0.063	0.400	0.795	0.067	0.138
13	63.0	0.320	0.155	0.525	0.753	0.112	0.135
14	86.5	0.005	0.611	0.384	0.061	0.754	0.185
15	62.0	0.353	0.229	0.418	0.742	0.156	0.099
16	60.0	0.212	0.725	0.063	0.571	0.416	0.013
17	61.0	0.322	0.332	0.346	0.683	0.240	0.077
18	72.0	0.061	0.225	0.714	0.657	0.163	0.180
19	61.0	0.914	0.068	0.018	0.821	0.156	0.023
20	69.5	0.051	0.478	0.471	0.536	0.351	0.113
21	69.0	0.071	0.306	0.623	0.648	0.211	0.141
22	62.5	0.865	0.047	0.088	0.825	0.091	0.084
23	63.0	0.136	0.339	0.525	0.694	0.209	0.097
24	63.0	0.949	0.016	0.035	0.908	0.046	0.046
25	61.0	0.836	0.107	0.057	0.753	0.201	0.046
26	60.0	0.233	0.601	0.166	0.611	0.359	0.030
27	75.5	0.009	0.958	0.033	0.123	0.871	0.006
28	107.0	0.000	0.006	0.994	0.034	0.017	0.949
29	64.5	0.335	0.041	0.624	0.808	0.034	0.158
30	76.0	0.020	0.706	0.274	0.306	0.608	0.086
31	80.5	0.019	0.436	0.545	0.341	0.451	0.208
32	78.5	0.032	0.269	0.699	0.489	0.263	0.248
33	75.0	0.023	0.580	0.397	0.356	0.523	0.121
34	71.5	0.071	0.054	0.875	0.740	0.043	0.217
35	78.0	0.047	0.083	0.870	0.640	0.074	0.286
36	72.0	0.022	0.796	0.182	0.320	0.631	0.049
37	86.0	0.013	0.367	0.619	0.240	0.465	0.295
38	67.0	0.041	0.941	0.018	0.365	0.632	0.003
39	89.0	0.017	0.157	0.826	0.342	0.223	0.435
40	87.5	0.011	0.081	0.908	0.225	0.133	0.642
41	97.0	0.019	0.081	0.900	0.248	0.138	0.614

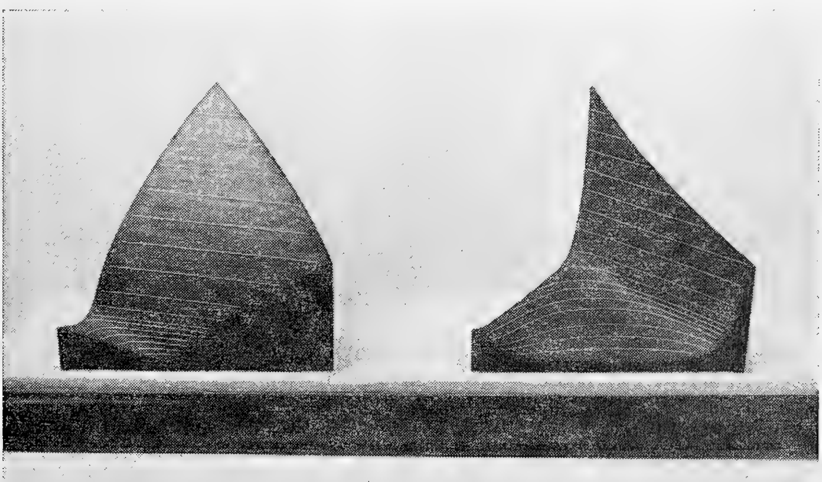

Fig. 1.—Three dimensional isobaric models of methanol-benzene-toulen vapor-liquid equilibria

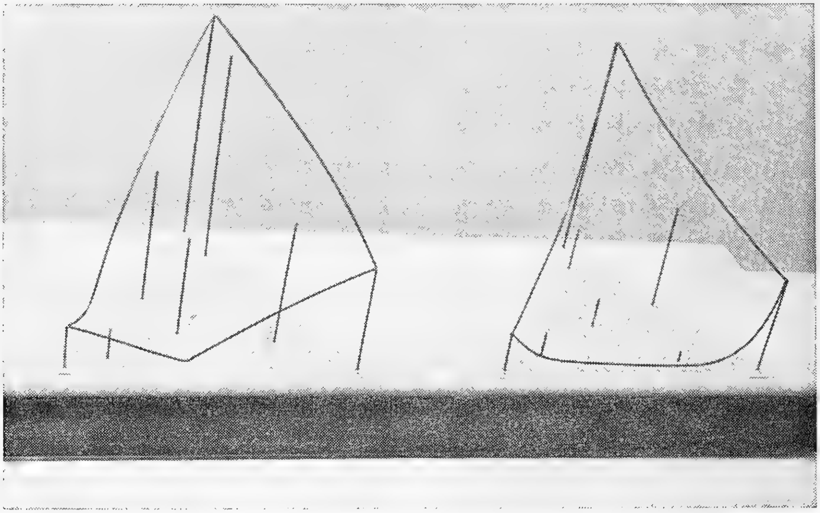

Fig. 2.— Construction details for three dimensional vapor-liquid equilibrium models

then a matter of forming the surfaces by filling in around the rods with a pliable material such as clay while using the ends of the rods as guides. These surfaces are shown in Figure 1. The vaporus surface is on the left and the liquidus on the right.

Horizontal traces on the developed surfaces produce isothermal-isobaric lines and are shown in white on Figure 1. These lines are represented in planar coordinates for the liquidus and vaporus surfaces in Figure 3 and Figure 4, respectively. Figures 5 and 6 show typical liquidus and vaporus lines with their corresponding tie lines at temperatures of 61°C and 65°C, respectively.

The location of the minimum boiling azeotropes for the binary systems methanol-benzene and methanol-toluene are indicated by the small circles on Figure 3 through Figure 6.

Discussion

The data obtained from the equilibrium distillations of the methanol-benzene-toluene system were used to construct the isobaric space models in the manner previously described. Since neither a maximum or minimum boiling point value exists on either the vaporus or the liquidus surface, the system does not contain a ternary azeotrope. The liquidus surface has the following characteristics:

1. The surface at the benzene-toluene edge drops off very sharply as methanol is added even by a small amount.

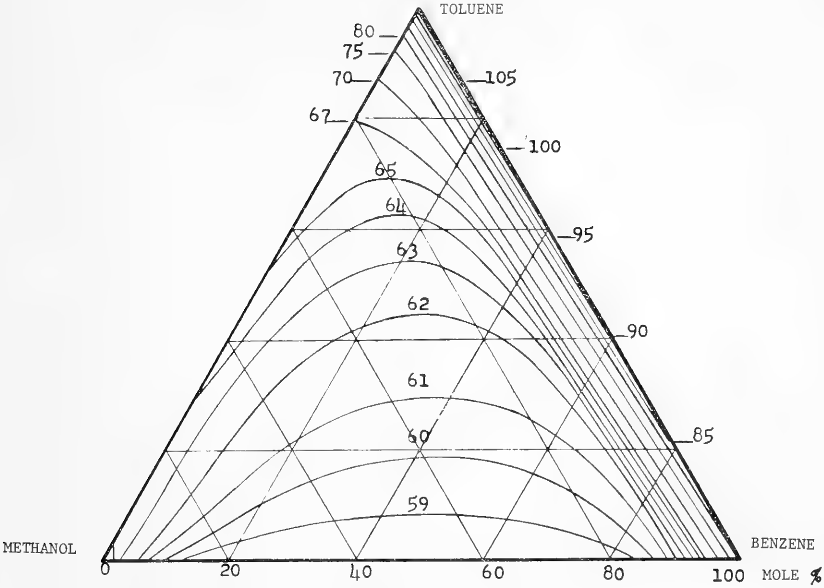

Fig. 3.— Isothermal traces on the liquids surface of the menthanol-benzene-toulene model (°C)

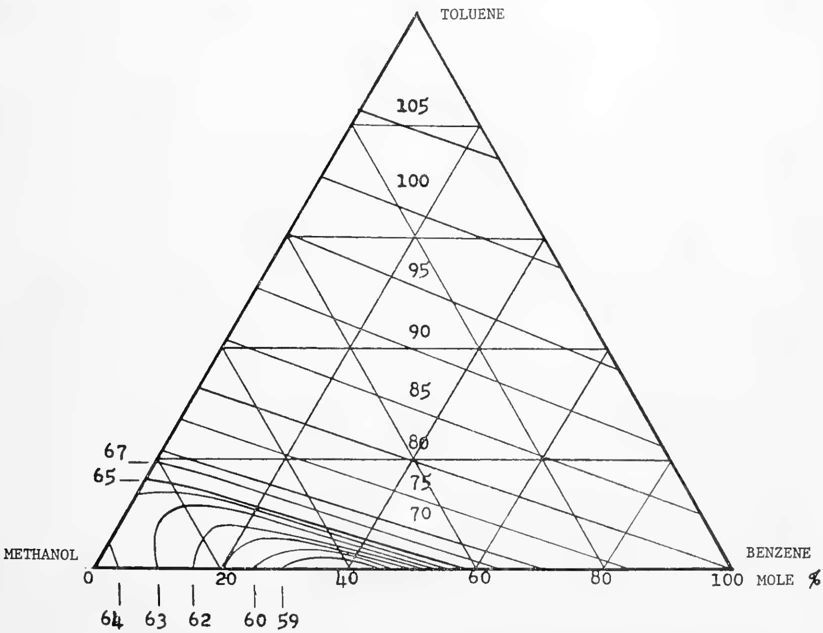

Fig. 4.— Isothermal traces on the vaporous surface of the methanol-benzene-toluene model (°C)

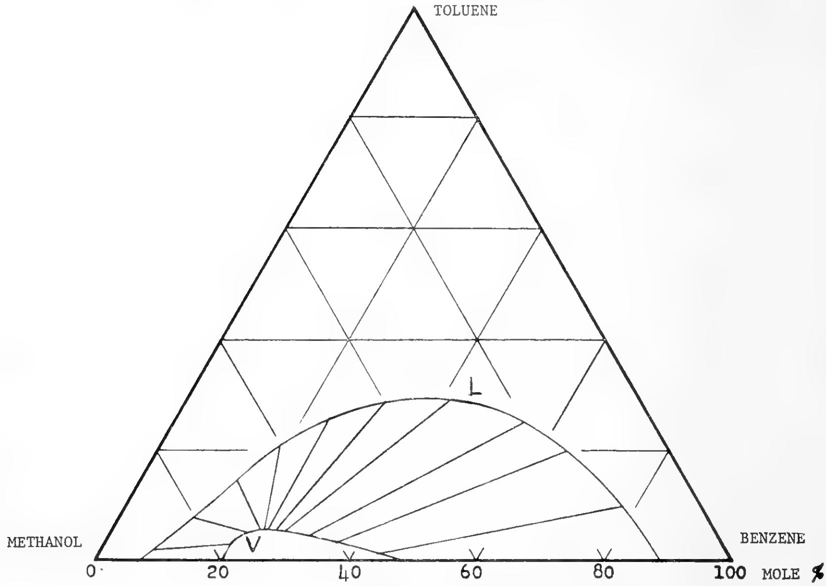

FIGURE 5. LIQUIDUS AND VAPORUS CURVES FOR METHANOL-BENZENE-TOLUENE AT 61°C

Fig. 5.— Liquids and vaporous curves for methanol-benzene-toluene at 61°C

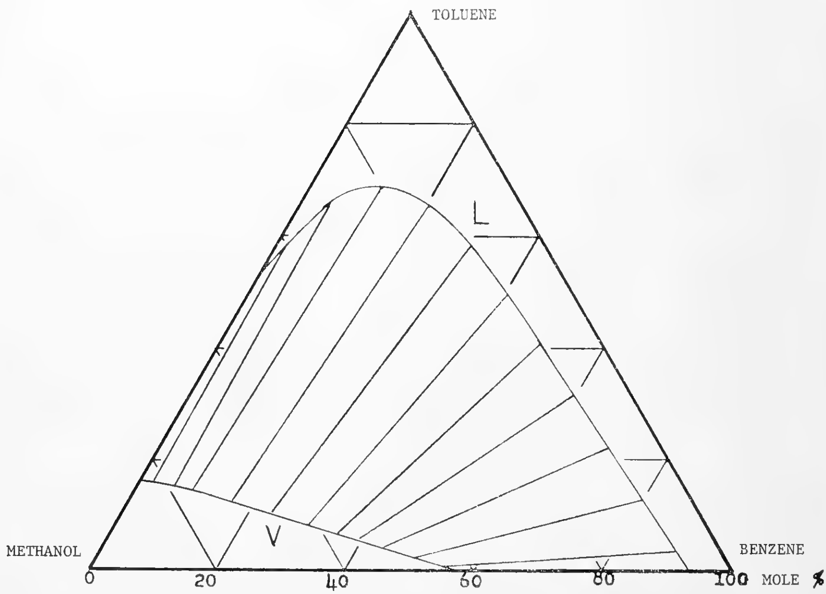

Fig. 6.— Liquids and vaporous curves for methanol-benzene-toluene at 65°C

2. The surface at the methanol-toluene edge drops off very sharply at extremely high concentrations of toluene but changes to a slight slope as the toluene concentration decreases.
3. The surface at the methanol-benzene edge gradually rises with a small slope until the concentrations of benzene and toluene become appreciable.

The vaporus surface has the following characteristics:

1. The surface at the methanol-toluene edge between the binary azeotrope of the system and pure toluene slopes evenly toward the benzene rich edges of the prism. Between pure methanol and the binary azeotrope the surface slopes slightly downward toward the "minimum trough" that exists between the two binary azeotropes in the ternary system.

2. The surface at the methanol-benzene edge rises gradually between the binary azeotrope and pure benzene. Between pure methanol and the binary azeotrope, the surface slopes downward toward the "minimum trough".

3. The surface at the benzene-toluene edge slopes slightly downward toward the center of the triangular prism.

The isothermal-isobaric lines on the liquidus surface for this ternary system form distorted, concentric partial ellipses around the lowest boiling point, which is the methanol-benzene minimum boiling azeotrope. The literature indicates that this effect would be anticipated in a system that did not contain a ternary azeotrope (3, 5, 6). However, on the vaporous surface the isothermal-isobaric lines first form a similar patter nof partial ellipses but as the toluene concentration increases the lines become straight. This effect was not anticipated but it is felt that if any curvature is present it is below the accuracy with which the models can be constructed.

Examination of Figures 5 and 6 shows that in the lower temperature (59° to 64°C) isobaric-isothermal lines, there is a gradual directional change in the tie lines. These tie lines may be estimated from tie line data obtained in the vapor-liquid analysis of the system. Although exact coincidence of boiling points and desired isothermal charts would be only fortuitous, the mass of tie line data obtained in the investigation gives excellent direction and estimation reference.

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PREPARATION OF PHENYL-*N*-SULFINYLHYDRAZINES USING DIMETHYLFORMAMIDE-SULFUR DIOXIDE REAGENT

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Phenyl-*N*-sulfinylhydrazines have been prepared by the reaction of phenylhydrazines with thionyl chloride (Michaelis, 1889), with sulfur dioxide in benzene (Michaelis, 1890), and with *N*-sulfinylaniline (Michaelis, 1892). We have found that a solution of sulfur dioxide in dimethylformamide provides a convenient reagent for the preparation of these compounds. The method is simple and direct and has been used to prepare phenyl-, 4-carboxyphenyl-, 2- and 4-nitrophenyl-, and 4-bromophenyl-*N*-sulfinylhydrazines in yields of 16-55%.

Experimental

Phenylhydrazine (2.2 g., 0.02 mole) and 60 ml. of a saturated solution of sulfur dioxide in dimethylformamide were placed in a flask fiitted with stirrer, condenser and calcium chloride tube. The solution was heated at 75-80° for 5 hours, cooled, diluted with 30 ml. of benzene and sufficient water to give two layers. The benzene was separated and the aqueous layer was extracted with two additional 30 ml. portions of benzene. The combined benzene extracts were washed with water and evaporated to dryness to give 1.7 g. (55%) of product, m.p. 104-6°.

The above procedure was used to prepare 4-bromophenyl-*N*-sulfinylhydrazine, m.p. 170-2° (34%); 4-nitrophenyl-*N*-sulfinylhydrazine, m.p. 213-14° (18%); 2-nitrophenyl-*N*-sulfinylhydrazine, m.p. 127-8° (recrystallized from 95% ethanol) (16%); and 4-carboxyphenyl-*N*-sulfinylhydrazine, m. p. 276-8° (54%). Since the literature (Klieesen, 1894) reports a melting point of 258° for this last compound, an analytical sample was prepared.

Anal. Calcd. for $C_7H_6N_2O_3S$: N, 14.14; S, 16.16.
Found: N, 14.35; S, 16.32.

4-Nitrophenyl-*N*-sulfinylhydrazine has not been previously reported.

Anal. Calcd. for $C_6H_5N_3O_3S$: N, 21.10; S, 16.10.
Found: N, 20.60; S, 15.85.

When a solution of 25 g. of phenylhydrazine and 100 ml. of a saturated solution of sulfur dioxide in dimethylformamide was refluxed for 6 hours, a 38% yield of phenyl-*N*-sulfinylhydrazine was obtained.

Acknowledgement

This research was supported by the Directorate of Chemical Sciences, Air Force Office of Scientific Research.

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THE SYNTHESIS OF PYRIDINE-2-^{14}C-1-OXIDE-4-AZO-*P*-DIMETHYLANLINE

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Chemistry Departments of the University of Kentucky, Lexington, Kentucky, and Seton Hall University, South Orange, New Jersey

In a study of a series of pyridine analogs of ρ-dimethylaminoazobenzene (Butter Yellow) as producers of hepatomas in rats, we found (Brown 1954) that pyridine-1-oxide-4-azo-ρ-dimethylaniline was the most active compound tested. Since this enhanced activity was attributed to the pyridine portion of the molecule, it was felt that the synthesis of pyridine-1-oxide-2-^{14}C-4-azo-ρ-dimethylaniline would enable us to investigate the mechanism of carcinogenic activity by radiotracer techniques. Hence a method of introducing the carbon-14 radionuclide into the alpha position of the pyridine molecule was sought.

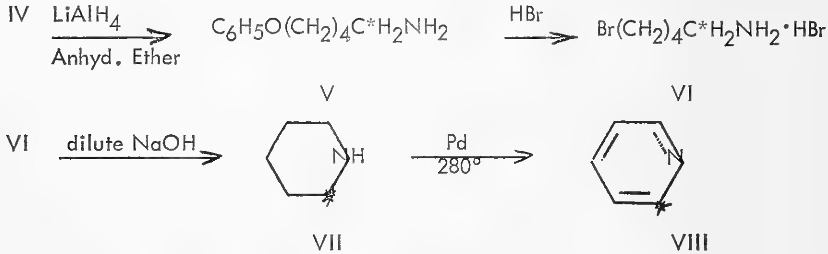
The total synthesis of pyridine-2-^{14}C-1-oxide-4-azo-ρ-dimethylaniline was accomplished in the following manner. Treatment of 1, 4-dibromobutane (1) with sodium phenoxide yielded 5-phenoxy-1-bromobutane (II). This was converted to the Grignard reagent which on reaction with carbon-14 dioxide gas gave a 75 percent yield of 5-phenoxypentanoic-1-^{14}C acid (III). Reaction of this acid with thionyl chloride and then gaseous ammonia gave an almost quantitative yield of 5-phenoxypentanamide-1-^{14}C(IV).

$$\underset{\text{I}}{Br(CH_2)_4Br} + C_6H_5ONa \longrightarrow \underset{\text{II}}{C_6H_5O(CH_2)_4Br} \xrightarrow[\text{2) } C^*O_2]{\text{1) } Mg}$$

$$\underset{\text{III}}{C_6H_5O(CH_2)_4C^*OOH} \xrightarrow[\text{2) } NH_3]{\text{1) } SO_2Cl} \underset{\text{IV}}{C_6H_5O(CH_2)_4C^*ONH_2}$$

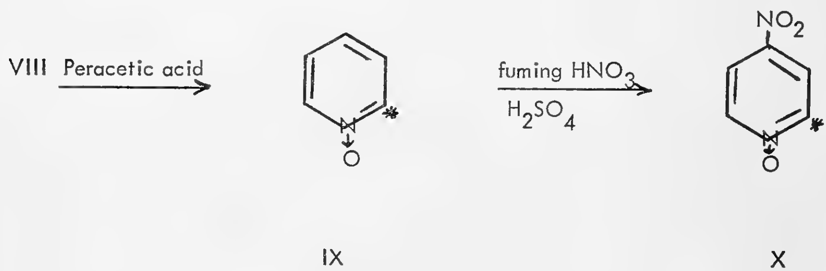
It was originally intended to convert IV to the corresponding amine by dehydration to the nitrile with phosphorus pentoxide, followed by reduction to the amine. However, this method proved impractical because of comparatively low yields. One-step reduction of IV was accomplished with lithium aluminum hydride in anhydrous ether to give an almost quantitative yield of 5-phenoxypentylamine-1-^{14}C. (V) The phenoxy ether portion of V was cleaved with 48 percent hydrobromic acid and the resultant 5-bromo-1-aminopentane-1-

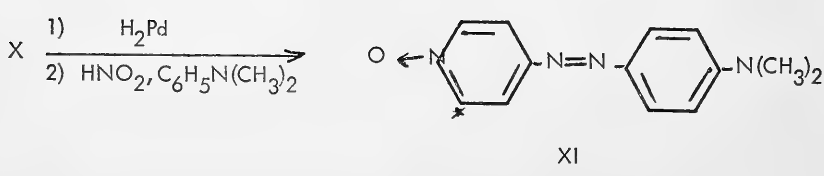
^{14}C (VI) was cyclized to piperidine-2-^{14}C (VII) with dilute sodium hydroxide.



Several methods were available for the oxidation of VII to pyridine-2-^{14}C (VIII); however, the apparatus and procedure of Finkelstein and Elderfield (Finkelstein 1939) for the dehydrogenation of alkyl piperidines was chosen because of high yields and simplicity of equipment. Yields of pyridine, by this method, in non-isotopic runs were about 90 percent. However, a lower yield was obtained in the isotopic run due to malfunction of the vaporizer tube heating element.

The dye intermediates and the final product were synthesized by the method of Faessinger and Brown (Faessinger 1951). Oxidation of VIII with peracetic acid afforded a 72 percent yield of pyridine-1-oxide-2-^{14}C hydrochloride (IX). The oxide was nitrated with a fuming nitric-sulfuric acid mixture to 4-nitropyridine-1-oxide 12-^{14}C (X). Low pressure hydrogenation of the nitrated product with palladium catalyst and hydrogen yielded 4-aminopyridine-1-oxide-2-^{14}C, which was not isolated. Diazotization of the amine and coupling of the resulting diazonium salt with dimethylaniline afforded a small yield of pyridine-1-oxide-2-^{14}C-azo-*p*-dimethylaniline (XI).





The yield of XI was comparatively low due to insufficient cooling during diazotization. However, non-isotopic runs afforded a 50 percent yield of final product.

Experimental

Radiometric Assay

The counting equipment was a Nuclear-Chicago Model 46-A, Q-Gas counter, windowless type, designed specifically for the measurement of soft beta radiation.

The counter was calibrated with a National Bureau of Standards sodium ^{14}C carbonate standard. The counting efficiency for the 0.138 MEV carbon-14 beta particle was ascertained to be 11.1 $\pm$3.01%.

1-Phenoxy-4-bromobutane (Marvel 1941) (II)

In a three-neck, two-liter round bottom flask, fitted with a long reflux condenser, ground glass stirrer and dropping funnel were placed 500 ml. of water, 250 g. (1.15 mole) of 1,4-dibromobutane (1) and 92.5 g. (0.98 mole) of phenol. The mixture was heated to boiling, and 37.5 g. (0.99 mole) of sodium hydroxide in 125 m l. of water was added over a period of about one hour. The mixture was then refluxed for five to six hours longer to complete the reaction. Upon completion of refluxing, the mixture was cooled to room temperature and the upper aqueous fraction was separated and discarded.

The lower layer was transferred to a 250 ml. Claisen flask and distilled under reduced pressure. The first fraction, collected up to 136° at 20 mm., consisted of water and recovered 1, 4-dibromobutane. The next fraction, collected at 153-56° at 16 mm., gave 141 g. (76%) of pure 1-phenoxy-4-bromobutane which, on cooling, crystallized to a whwhite solid, m.p. 41°, lit. (Marvel 1922) m.p. 41°, b.p. 153-56° at 18 mm.

5-Phenoxypentanoic-1-^{14}C Acid (III)

The carbonation apparatus (Calvin 1949) consisted of a gas generating flask containing 1.46 g. of barium carbonate (0.2296 g., 16 Mc $Ba^{14}CO_3$ and 1.1304 g. of carrier $BaCO_3$), a drying train containing "Drierite", and a carbonation flask containing the Grignard reagent. The Grignard reagent had been previously prepared from 4.0 g. (0.01 mole) of 1-phenoxy-4-bromobutane and 0.4 g. (0.017 g. atom) of magnesium turnings in 100 ml. of anhydrous ether. A magnetic stirrer was provided for the carbonation flask. When the system had been thoroughly flushed with nitrogen, all stopcocks were closed and the carbonation flask was cooled with liquid air. Once the Grignard reagent had solidified, the system was partially evacuated, with continued cooling, sulfuric acid was added slowly (to avoid foaming) through the dropping funnel and the evolved carbon dioxide gas was allowed to completely pass into the carbonation flask, where it solidified. Then the liquid air was replaced by a cooling mixture of dry ice and acetone and the system was allowed to slowly rise to room temperature, with stirring, in about one hour.

After the mixture was hydrolyzed by the slow addition of 75 ml. of 25% sulfuric acid, it was transferred to a 250 ml. separatory funnel. The ether layer was separated and the aqueous phase was extracted with two 50 ml. portions of ether. The ether extracts were combined in another 250 ml. separatory funnel where the organic phase was washed with three 30 ml. portions of 25% sodium hydroxide. The alkaline washings were combined in a distilling flask where they were evaporated to approximately 10% of the original volume in order to remove any residual ether and other volatile impurities. The solution was cooled, acidified with cold hydrochloric acid and the resultant precipitated acid was filtered, washed with cold water and air dried. Recrystallization from petroleum either afforded 1.12 g. (78%) of 5-phenoxypentanoic-1-^{14}C acid, m.p. 64-5°, lit. (Gabriel 1892) m.p. 65-66°

5-Phenoxypentanamide-1-^{14}C (IV)

5-Phenoxypentanoic-1-^{14}C acid was diluted to a total weight of 6.8 g. (0.035 mole) with carrier 5-phenoxypentanoic acid and placed in a 250 ml. suction flask whose sidearm was fitted with a calcium chloride drying tube. After the addition of 100 ml. of anhydrous ether, 40 ml. (0.55 mole) of thionyl chloride and 0.25 ml. of pyridine were added. The flask was stoppered, swirled, allowed to stand for ten minutes and gently heated on a steam bath for fifteen minutes; then the ether and excess thionyl chloride were evaporated under reduced pressure. Removal of the final traces of thionyl chloride was aided by the addition of 15 ml. of benzene.

To the acid chloride residue was added 100 ml. of anhydrous ether. The flask was cooled in an ice-salt bath and anhydrous ammonia bubbled through the solution until no more ammonia was absorbed. The resulting precipitate was filtered, air dried and recrystallized from toluene to give 6.3 g. (94.0%) of phenoxypentanamide-1-^{14}C melting at 104°. Anal. calcd. for $C_{11}H_{15}NO_2$: C, 68.39%; H, 7.83%. Found: C, 68.34%; H, 7.69%.

5-Phenoxy-1-pentylamine-^{14}C (V)

In a thimble of a Soxhlet extractor was placed 6.3 g. (0.033 mole) of 5-phenoxypentanamide-1-^{14}C and in the boiler of the extractor was placed 3.8 g. (0.01 mole) of lithium aluminum hydride in 300 ml. of anhydrous ether. The ether was refluxed for approximately twenty-six hours after which the flask was cooled in an ice-salt bath and the reaction mixture hydrolyzed. Hydrolysis was affected by the slow addition, with stirring, of 4 ml. of water, 4 ml. of 15% NaOH and 15 ml. of water, respectively. After vigorous stirring for twenty minutes, the mixture was filtered with suction and the granular precipitate was washed thoroughly with ether. The filtrate and washings were combined and dried over anhydrous potassium carbonate. Filtration of the drying agent followed by removal of the ether by distillation at reduced pressure gave 5.1 g. (94.0%) of 5-phenoxy-1-pentylamine-1-^{14}C, b.p. 274-76°, lit. (Gabritl 1892), b.p. 274-76°.

Piperidine-2-^{14}C (VII)

In a 250 ml. round-bottom flask, fiitted with a reflux condenser was placed 5.1 g. (0.028 mole) of 5-phenoxy-1-pentylamine-1-^{14}C and 100 ml. of 48% hydrobromic acid solution. The solution was refluxed for four hours, cooled and added dropwise, with vigorous mechanical stirring, into two liters of 20% sodium hydroxide solution. An additional 30 g. of sodium hydroxide pellets were added and the flask was allowed to stand for one hour, with occasional swirling. The solution was steam distilled until all the piperidine had been removed. The distillate was rendered strongly alkaline with sodium hydroxide and then extracted with ether. After the ether extract was separated and dried over sodium hydroxide pellets, the drying agent was removed by filtration. Removal of the solvent by distillation gave 2.2 g. (85.0%) of piperidine-2-^{14}C, b.p. 104°, lit. (Ruzicka 1920) b.p. 104°

Pyridine-2-^{14}C (VIII)

The apparatus utilized for the preparation of pyridine was similar to the one outlined by Finkelstein and Elderfield (Finkelstein 1939). The catalyst was prepared by shaking acid washed, alkali washed, ignited asbestos fiber in 130 ml. of 0.46% palladium chloride solution under hydrogen at 3 atmospheres pressure. The palladized asbestos was filtered, washed until neutral and dried in an oven at 100°

In the vaporizer tube was placed 2.2 g. (0.026 mole) of piperidine-2-^{14}C. The catalyst tube was heated to 290° by means of a furnace. A slow stream of nitrogen was admitted through a three-way stopcock until all the air in the system had been displaced. A slow stream of hydrogen was then substituted for the nitrogen, and the vaporizer tube was heated to 90° (no higher) with a heating mantle. The passage of gas was continued for seven hours, when all the piperidine in the trap had been carried over. One gram (48.8% of theoretical) of pyridine-2-^{14}C was obtained, b.p. 115°

Pyridine-1-Oxide-2-^{14}C Hydrochloride (IX)

A mixture of 1 g. (0.0126 mole) of pyridine-2-^{14}C and 2 g. of ice were placed in a 50 ml. Erlenmeyer flask and 2.5 ml. of 40% peracetic acid was added with stirring. The reaction mixture was allowed to stand for six hours at a temperature no greater than 80°. Finally, the reaction mixture was heated for two hours on a steam bath.

On cooling, 1.5 ml. of concentrated hydrochloric acid was added. The mixture was transferred to a 125 ml. distillation flask fitted with a capillary tube and the flask was heated on a steam bath under reduced pressure until the solution had evaporated to dryness. After the residue was taken up in a minimum amount of hot ethanol, the solution was filtered and allowed to cool slowly. On cooling, crystalline columns of pyridine-1-oxide-2-^{14}C hydrochloride were formed. When the solution had cooled to room temperature, absolute ether was added to precipitate the remaining product, which afforded 1.2 g. (72.2%) of pyridine-1-oxide-2-^{14}C hydrochloride, m.p. 180-1°, counts/minute 1.21×10^8, (Disintegrations/minute 1.09×10^9).

4-Nitropyridine-1-Oxide-2-^{14}C (X)

The hydrochloride salt IX, 1 g. (0.009 mole) was placed in a 50 ml. breaker and 2.4 ml. of concentrated sulfuric acid was added at such a rate that the hydrogen chloride gas which was evolved did not cause excessive frothing. The acid solution was stirred for a few minutes to liberate all the hydrogen chloride gas present. The solution was then poured slowly into a nitrating mixture consisting of 4 ml. of fuming nitric acid and 2.4 ml. of concentrated sulfuric acid. Finally, the mixture was heated at 90° for four hours.

On completion of nitration, the solution was cooled in an ice bath and neutralization was affected by addition (in small portions) of sodium carbonate with continued stirring and external cooling. Upon completion of neutralization, the resulting fine, yellow powder was spread out to air dry for two hours.

The powder was extracted with five 100 ml. portions of hot benzene and the solvent was filtered. Distillation of the solvent under reduced pressure yielded 0.6 g. (52.6%) of 4-nitropyridine-1-oxide-2-^{14}C, m.p. 155-60°, counts/minute 6.60×10^7 (Disintegrations/minute 5.95×10^8).

Pyridine-1-Oxide-2-^{14}C-4-azo-ρ-Dimethylaniline (XI)

In a Parr bottle was placed a mixture of 0.6 g. (0.0043 mole) of 4-nitropyridine-1-oxide-2-^{14}C, 25 ml. of water and 1 microspatula of 5%

palladium on charcoal catalyst. Hydrogenation was carried out in a Parr Low Pressure Hydrogenation unit at a pressure of 45 psi and continued until no more hydrogen was absorbed (about 1-½ psi). On completion of reduction, 0.5 ml. of concentrated hydrochloric acid was added and the solution was filtered. The filtered catalyst was washed with 25 ml. of water and the wash was combined with the filtrate. The combined filtrate and wash was transferred to a 125 ml. three-necked flask and the flask was cooled (ice-salt mixture), with stirring, to approximately 0 to –5°. One ml. of concentrated hydrochloric acid was added and the solution was diazotized with 0.31 g. (0.0043 mole) of sodium nitrite over a period of twenty minutes, at 0 to –5°. Stirring was continued for ten minutes, after which a coupling solution containing 0.52 g. (0.0043 moles) of dimethylaniline, 8 ml. of 70% ethanol and 1 g. of sodium acetate, was added at 0 to –5° over a twenty-minute period. After continued stirring for another one-half hour, the solution was neutralized with ammonium hydroxide. The resultant precipitated dye was filtered, washed with water and dried. Recrystallization from 95% ethanol gave 20 mg. (0.18%) of pyridine-1-oxide-2-^{14}C-4-azo-*p*-dimethylaniline, m.p. 218-19°, lit. (Faessinger 1951), m.p. 218-19°, counts/minute 1.00×10^6, (Disintegrations/minute 9.01×10^5).

Acknowledgement

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MEGASPOROGENESIS IN *LABURNUM ANAGYROIDES* MEDIC.— A CASE OF BISPORIC DEVELOPMENT IN LEGUMINOSAE

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Introduction

Laburnum anagyroides Medic. is a papilionaceous member of the plant family Leguminosae. According to Bailey (1949), this cultivated species occurs naturally from Central to Southern Europe. Floral buds of *L. anagyroides* were collected on the campus of the University of Kentucky in the spring of 1965 and 1966 and fixed in FPA_{50} (formalin-propionic acid-50% ethyl alcohol) for at least 24 hours. Ovaries were excised, dehydrated, embedded, and sectioned at 8-10 microns. Drawings, made with the aid of a camera lucida, are reproduced at magnifications indicated on the plates.

Observations

In *Laburnum anagyroides* Medic. six to nine ovules begin development in the monocarpellate ovary. A hypodermal aschesporial cell, which forms in the young nucellar mass, divides periclinally to produce a parietal cell and a primary sporogenous cell (Fig. 1). Periclinal division of the parietal cell (Fig. 2) contributes to the nucellar mass. The primary sporogenous cell enlarges to form the megasporocyte (Fig 3). Continued divisions of the parietal cell derivations give evidence for crassinucellate development of the nucellus. The megasporocyte undergoes the first meiotic division to form a dyad (Fig. 4). The micropylar member of the dyad undergoes the second meiotic division and the two megaspores formed begin to degenerate (Fig. 5). A second meiotic division in the chalazal member of the dyad is delayed and is not followed by cytokinesis (Fig. 6). Two megaspore nuclei incorporated within this cell both contribute to the development of the megagametophyte. This is evidence for a bisporic development for *L. anagyroides.*

In addition to the above pattern of megasporogenesis, another has been observed for *L. anagyroides.* A multicellular archesporium, composed of as many as three archesporial cells, may develop. Each archesporial cell may divide pericinally to produce a parietal cell and a primary sporogenous cell. Three such primary sporogenous cells

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are represented in figure 7. Figure 8 demonstrates two primary sporogenous cells each with parietal cell derivatives. The primary sporogenous cells continue to enlarge to form megasporocytes while continued divisions of parietal cell derivatives contribute to the crassinucellate nucellus (Fig. 9). Both megasporocytes may proceed with the first meiotic division to form dyads (Fig. 10). At least one of these dyads may continue development with the micropylar member undergoing meiosis II (Fig. 11). Regardless of how megasporogenesis progresses, i.e., with a single hypodermal archesporial cell or with multicellular archesporium, only one megagametophyte develops.

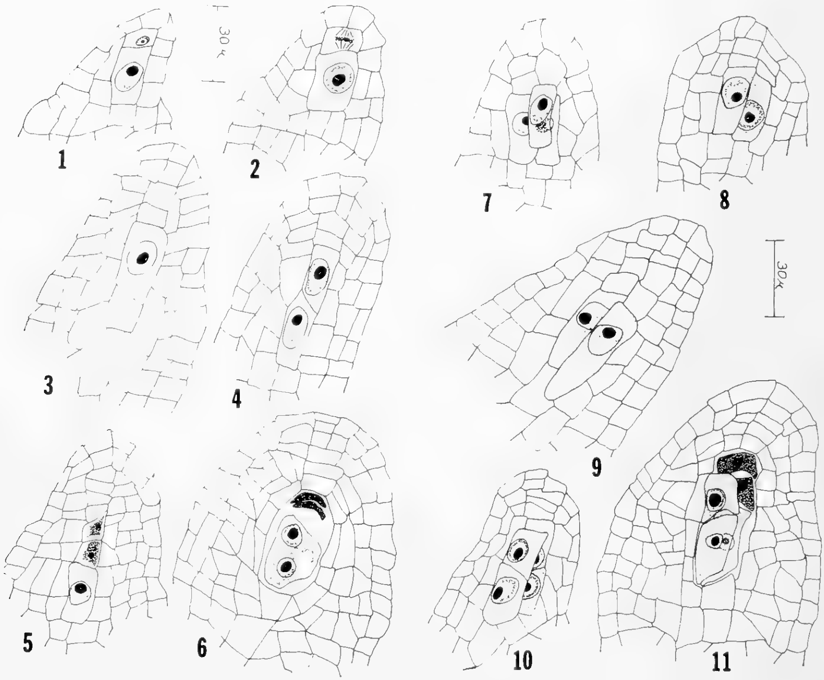

Figure 1-11

Discussion

According to Maheshwari (1950), Strasburger was the first to describe bisporic development in 1879. Strasburger's description was made on *Allium fistulosum* and hence this is referred to by Maheshwari as *Allium* type of development. B. M. Johri (1963) recognizes a second type of bisporic development which he calls *Endymion* type. *Laburnum anagyroides*, as described here, follows the *Allium* type of

Maheshwari (1950). S. C. Maheshwari (1955) made a critical review of all reports of bisporic development in angiosperms and concluded that bisporic development has been established in only 30 angiosperm families. Several disputed cases of bisporic development are also reviewed by Maheshwari (1955). Of these, two are from Leguminosae; *Lupinus luteus* and *L. polyphyllus* described by Guignard (1881) and according to Maheshwari, *Lathyrus odoratus* described by Jönsson (1879/1880). Maheshwari considers both of the above reports doubtful and in need of reinvestigation. In any case, the present work concerning *Laburnum anagyroides* is the only reported observation of bisporic development in Leguminosae since 1881. This author has also observed bisporic development in *Wisteria sinensis* (Sims) Sweet but as yet this work is unpublished.

Bisporic development should be considered a derived condition in the embryological development of the angiosperms as it represents the loss of a cell wall, i.e., failure of cytokinesis following meiosis II in the chalazal member of the dyad. It is significant that all reported cases of bisporic development in Leguminosae have come from the subfamily Papilionoideae, morphologically the most advanced.

Acknowledgement

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Figure Descriptions

Figure 1-11 Megasporogenesis in *Laburnum anagyroides* Medic.

Figure 1—Primary sporogenous cell and parietal cell.

Figure 2—Primary sporogenous cell with parietal cell in metaphase.

Figure 3—Megasporocyte

Figure 4—Dyad

Figure 5—Two degenerating megaspores with chalazal member of dyad.

Figure 6—Two degenerating megaspores with chalazal member of dyad.

Figure 7—Three primary sporogenous cells.

Figure 8—Two primary sporogenous cells

Figure 9—Two megasporocytes

Figure 10—Two dyads

Figure 11—One dyad on top af the chalazal member of a second dyad with two degenerating megaspores.

REDUCTION IN NUMBER OF MUCOUS CELLS IN THE OLFACTORY ORGANS OF *NOTROPIS LUTRENSIS* (BAIRD AND GIRARD) AND *NOTROPIS CAMURUS* (JORDAN AND MEEK) FOLLOWING TREATMENT WITH NICOTINE ALKALOID*

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Because of its remarkable morphological constancy, (Allison, 1953) and ease of manipulation, the piscine olfactory organ should be of special interest to histologists and physiologists. In fishes, the olfactory region constitutes about one-sixth of the brain, and is probably the least understood of their sense organs.

The external olfactory opening of Notropis, as in most bony fishes, is divided by a nasal flap into anterior, and posterior nostrils. This nasal flap extends outward from the pore for approximately one-half millimeter. Environmental water is circulated through the olfactory chamber by means of internal ciliation and by swimming motions because of nasal flap configuration (Branson, 1963).

Internally, the olfactory lamellae are arranged in a rosette pattern. In our experimental fishes, this rosette consists of a central lamella and a total of 18 radial lamellae, nine above and nine below the central one. This figure may not be constant, since observations in other species of fishes have demonstrated variation in the number of radial lamellae (Branson, 1963). In general, the number of lamellae increases with the increase in size. It was not here determined whether the observed constancy in lamellar numbers was of a specific nature, since all specimens utilized were in the same size range.

The epithelial lining of the lamellae is continuous with the external epidermis and is pseudostratified. There are three main types of cells in the olfactory epithelium: receptor cells, supporting cells, and basal cells. The receptor cells are supplied with sensory hairs which function in olfaction, whereas, the supoprting cells are ciliated. Mucous, or goblet, cells are present in varying numbers per 100 microns of tissue, the average figure being approximately one (0-7).

Nicotine, an alkaloid, is one of the most violent poisons known. As far as fishes and other aquatic life are concerned, the toxicity appar-

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ently increases with the nervous complexity of the organism (Anon, 1952), and the substance has a greater toxicity in alkaline solutions than in acid (Rudolfs, 1952). Most experimental work done with nicotine, in relation to olfaction, has been physiological. Apparently, very little has been accomplished as regards discerning the drug's histological effects. Consequently, the authors decided to test its effects, utilizing the number and size of mucous cells for the purpose of assay.

The fishes used in our experiments, all approximately equal in size (15.0 to 17.0 mm in standard length) were collected from Cow Creek and Spring River in southeastern Kansas, and placed in a laboratory holding tank until required. During experimentation, specimens were kept in battery jars containing three liters of water. Tap water, used in all experiments, was aerated 24 hours before utilization, aeration being continued until termination of each experiment. Nicotine was added to the water and mixed thoroughly before the fish were transferred. Each experiment was started at one part per million and gradually increased to 2.5 ppm. The test animals were changed to fresh solutions every third day and were fed commercial minnow food prior to this change.

Following nicotine treatment, specimens were killed and fixed in P.F.A.$_3$, a modified Bouin's solution (Jones et al., 1950), decapitated, embedded in paraffin (58°F. melting point), and sectioned at ten microns in frontal, cross, and sagittal planes. The sections were stained with Mallory's triple connective tissue stain (Guyer and Bean, 1953). All measurements were made by means of a filar micrometer.

Observations and Discussion

In all concentrations, experimental fishes rose to the suface within three to five minutes after being placed in the nicotine solution. They remained at the surface from five to fifteen minutes, probably because nicotine affects proper functioning of the gills, since the operculum became extended more than normal and the rate of branchial irrigation increased. Paintal (1957) found that pulmonary deflation receptors are stimulated and sensitized by nicotine. Some similar mechanism may be operative here.

In one experiment, the concentration of nicotine was increased by 0.5 parts per million (ppm) every four days. The specimens died at 2.5 ppm after being in the solution for one hour. Fishes kept in two parts per million began dying at eight days and were all dead by twelve days. However, fishes put directly into 2.5 parts per million lived for 16 days, at which time the experiment was terminated. The difference here noted may be a question of a differential rate of absorption of the drug, but this will have to be ascertained by additional research.

Six days after the fishes were put into the 2.5 ppm solution, mucous was noted extending from the olfactory pores and was continually secreted into the water throughout the remainder of the experiment. From this observation we concluded that either the number or the size of the goblet cells had increased. Following sectioning, the number of goblet cells per 100 microns of linearly measured epithelium was ascertained and evaluated by means of the Student T-Test, indicating statistically fewer goblet cells in the experimental fishes. In the controls, of the 2.5 ppm experiment, the average number of goblet cells per 100 microns was 1.1 (0 to 7), whereas in the experimental fishes the average was 0.76 (0 to 4). No significant difference in size of the goblet cells were noted. This reduction in number was possibly the result of heightened activity and subsequent degeneration of the goblet cells. Working with white rats, parallel results were obtained by Vinnikov (1956), who showed that vertebrate olfactory tissue not only has negligible regenerative ability, but that it has a great tendency to degenerate when damaged. In his organisms, such damage-induced degeneration of olfactory cells, nerve fibers, and elements of the vomeronasal organ, spread to the opposite side of the body, and at the end of a six-month period no visible regeneration was detected.

No other obvious histological results were observed. However, longer exposure to nicotine might produce results of a grosser nature. In physiological experiments, adenosine triphosphate has been found to intensify the action of nicotine in plants (Howard Stein, Pers. Comm.). Combinations similar to this might also prove productive from a histological standpoint in animals. Whatever the case, the tendency toward goblet-cell degeneration should be studied in more detail over a longer period of time, and fishes are admirably suited for such research.

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PREPARATION OF SOME AMINO DERIVATIVES OF HALOGENATED PHENOLS

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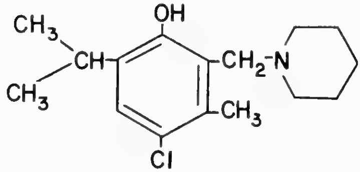
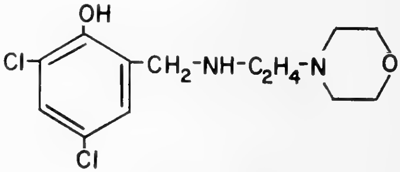
As a result of some earlier work in this laboratory by Meadow and co-workers[1] on the preparation of compounds having possible therapeutic value, a patent was issued to Geschickter and Meadow[2] covering the products of some phenol derivatives with formaldehyde and amines which showed antihistaminic properties. Amino groups were introduced into poly-substituted phenols by means of the Mannich reaction using a method described previously by Meadow and Reid.[3] It was observed that some of these amino derivatives, particularly the compounds of some halogenated phenols, were unique in possessing the property of being both antihistaminic as well as bronchial dialators. An example of such a derivative is 2-piperidinomethyl-6-chlorothymol (I). Fortunately this compound, as well as the morpholinomethyl derivative of 6-chlorothymol, has a reasonably low toxicity value as indicated in Table I. The toxicity values of some of these physiologically active free bases which we previously synthesized (1) are listed in Table I. Included here also are melting point data for some salt derivatives of these compounds.

In view of the favorable results obtained from physiological tests with modified halogenated phenols, our work has been extended to include some new Mannich condensation products of such halogen-containing phenols with several primary and secondary amines. The use of a primary amine in Mannich reactions with phenols is not common. Pror to 1942 Blicke[4] recognized the fact that the literature contains no reports of successful Mannich condensations involving phenols and primary amines. Few instances have been observed since then.[5] Accordingly, we have attempted to combine several primary amines with some halogenated phenols with the aid of formaldehyde, and these compounds are reported as free bases in Tables II and III. The compounds obtained in this work with primary amines consisted entirely of the single condensation product of one mole of phenol with one mole of amine, thus producing products which contained a secondary amine functional group (II). Such compounds might be expected to undergo further reaction with a phenol to form a tertiary amine. However, attempts in this direction led to failure.

In addition to the compounds from primary amines shown in Tables II and III, eight new Mannich derivatives were prepared from halogenated phenols using three cyclic secondary amines which were not previously reported. These amines were 2,6-dimethylmorpholine, hexamethyleneimine, and N-hydroxyethylpiperazine. These derivatives are listed in Tables IV and V. These compounds are being further investigated for their physiological properties.



(I)



(II)

Experimental

In general, commercial grades (practical or reagent grades) of reactants were used with no further purification. All reactions utilized an aqueous solution of formaldehyde (approximately 37% by weight). N-(2-aminoethyl)morpholine and N-(3-aminopropyl)morpholine were purchased in practical grade from vendors. The technique employed in the syntheses of these Mannich compounds was similar to that of Meadow and Reid[3]; modifications were utilized chiefly in the isolation of the product from the reaction mxture. In most cases, a molar ratio of phenol to amine to formaldehyde of 1:3:3 was used. The reactants were mixed cold, and later refluxed at the temperature of boiling ethanol for periods varying from three to twelve hours. In most cases, a crysatlline product was obtained by chilling the reaction mixture for periods of a few hours or longer. Products were recrystallized from either methanol or 95% ethanol; generally, two such recrystallizations were carried out after which the purified compound was dried for several hours at 50-60°C in a vacuum oven. All melting points were determined with a Fisher-Johns type of block which had been checked with compounds having known melting points.

Preparation of Mono-Mannich Derivatives: 4-Chloro-6-(N-hydroxyethylpiperazinomethyl)-2-isopropyl-5-methylphenol is representative of some of the mono-Mannich derivatives prepared. A mixture of 5.55 g. (0.03 mole) of 6-chlorothymol, 6.5 g. (0.05 mole) of N-hydroxyethylpiperazine, and 15 ml. of absolute ethanol was cooled in an ice bath to below 5°C., and 4.7 g. (0.05 mole) of 35-40% aqueous formaldehyde was added slowly over a 15-minute period with shaking and cooling. After standing about one hour at room temperature, a condenser was attached to the flask and the mixture was then refluxed for about 4 hours. The resulting thick syrupy solution was diluted with 400 ml. of tap water and contents stirred. Small white oily lumps usually

Table I. Toxicities and Melting Point Data for Mannich Derivatives from Halogenated Phenols[a]

Mannich group added to phenol	Toxicity of Free Base[b]	*Melting Points for Salt Derivatives of Mannich Free Bases[c]* Hydrochloride (HCl), °C.	Oxalate ($H_2C_2O_4$) °C.	Dimethanesulfonamide $(CH_3SO_2)_2NH$, °C.
From 6-Chlorothymol				
Dimethylaminomethyl	150 mg/kg	166-7	137-8	122-3
Diethylaminomethyl	200 mg/kg	159-60	72-4	110-12
Morpholinomethyl	400 mg/kg	188-90 dec.	170-1° dec.	148-9
Piperidinimethyl	1000 mg/kg	220.5-2	184-5	173-4.5
Pyrrolidinomethyl	250 mg/kg	163-4[d]	156.5-7	139-40
From 3,5-Dimethyl-4-chlorophenol				
Morpholinomethyl (Mono-Mannich deriv.)	400 mg/kg	209-10	194-5	185-6.5
Morpholinomethyl (Di-Mannich deriv.)	200 mg/kg	224-5 dec.	172-3	170-70.5

[a]Melting points and analytical data for these Mannich free bases were reported previously by Berger, Byrd and Meadow (1958).[1] [b]Toxicity values represent lethal dose of free base in milligrams per kilogram rat necessary to kill 50% of animals tested. Tests were made by Dr. C. F. Geschickter of Georgetown University; solutions of the free base in dimethanesulfonamide were generally used. [c]Salt derivatives were conveniently made from the Mannich free base by addition of a slight excess of acid in limited volume of aqueous solution and recrystallizing once from water or ethanol. [d]This particular salt was solvated and loss was noted between 65° and 80°C. An accurate melting point can be obtained only when the salt is previously dried in at oven at 90-100°C for one hour or more.

Table II. Composition and Melting Points of Mannich Derivatives from Primary Amines

Compound Number	Phenol Employed	Amine Used	Empirical Formula	M.P. of Free Base, °C.
1	2,4-Dichloroprenol	Allyl amine	$C_{10}H_{11}NOCl_2$	122-3°
2	2,4-Dichlorophenol	N-(2-Aminoethyl)morpholine	$C_{13}H_{18}N_2O_2Cl_2$	150-1
3	2,4-Dichlorophenol	N-(3-Aminopropyl)morpholine	$C_{14}H_{20}N_2O_2Cl_2$	138-9
4	2,4-Dichlorophenol	n-Butyl amine	$C_{11}H_{15}NOCl_2$	115-5-6
5	2,4-Dibromophenol	Allyl amine	$C_{10}H_{11}NOBr_2$	155-6
6	2,4-Dibromophenol	N-(2-Aminoethyl)morpholine	$C_{13}H_{18}N_2O_2Br_2$	156.5-7
7	2,4-Dibromophenol	N-(·3-Aminopropyl)morpholine	$C_{14}H_{20}N_2O_2Br_2$	140-1
8	2,4-Dibromophenol	n-Butyl amine	$C_{11}H_{15}NOBr_2$	173-4
9	2,4,5-Trichlorophenol	Allyl amine	$C_{10}H_{10}NOCl_3$	157-8
10	2,4,5-Trichlorophenol	N-(2-Aminoethyl)morpholine	$C_{13}H_{17}N_2O_2Cl_3$	161.5-2
11	2,4,5-Trichlorophenol	N-(3-Aminopropyl)morpholine	$C_{14}H_{19}N_2O_2Cl_3$	160-1.5
12	2,4,5-Trichlorophenol	n-Butyl amine	$C_{11}H_{14}NOCl_3$	139-40

Table III. Analytical Data for Mannich Derivatives of Primary Amines

Compound Number[a]	Equivalent Weight		Per Cent Nitrogen[c]		Carbon-Hydrogen Determination[d]			
					%C		%H	
	Calculated	Found	Calculated	Found	Calc'd.	Found	Calc'd.	Found
1	232.1	233.1			51.74	51.95	4.78	4.81
2	152.5	153.2	9.18	9.19	51.16	51.08	5.94	5.94
3	159.6	160.1	8.78	8.61				
4	124.1	124.7	5.65	5.45				
5	321.0	322.3			37.41	37.52	3.45	3.61
6	197.0	197.7	7.11	7.09				
7	204.1	205.2	6.86	6.79				
8	337.1	338.8	416	4.06	39.19	39.66	4.49	4.72
9	268	271	5.26	5.02				
10	169.8	171.3	8.25	8.13	45.97	45.93	5.05	5.10
11	176.8	178.0	7.70	7.79	47.55	47.53	5.42	5.41
12	282.5	283.6	4.96	4.82				

[a]Number here refers to same compound described in Table II. [b]Equivalent weights determined by method of Seaman and Allen (1951).[6] [c]Per cent nitrogen by Kjeldahl method. [d]Carbon and hydrogen combustions were carried out by Weiler and Strauss, Oxford, England.

Table IV. Composition and Melting Points of Mannich Derivatives from Some Cyclic Secondary Amines and Halogenated Phenols[a]

Compound Number	Phenol	Amine	Emp. For.	M.P. °C.
1	4-Bromophenol	2,6-Dimethylmorpholine	$C_{16}H_{31}N_2O_3Br$	128.5-30
2	6-Chlorothymol	2,6-Dimethylmorpholine	$C_{17}H_{26}NO_2Cl$	78-9
3	6-Chlorothymol	N-Hydroxyethylpiperazine	$C_{17}H_{27}N_2O_2Cl$	102.5-3.5
4	6-Chlorothymol	Hexamethyleneimine	$C_{17}H_{26}NOCl$	44-4.5
5	4-Chloro-3,5-dimethylphenol	2,6-Dimethylmorpholine	$C_{15}H_{22}NO_2Cl$	115-7
6	2,6-Dichlorophenol	2,6-Dimethylmorpholine	$C_{13}H_{17}NO_2Cl_2$	134-7[b]
7	2,4-Dichlorophenol	2,6-Dimethylmorpholine	$C_{13}H_{17}NO_2Cl_2$	91-2
8	2,4,5-Trichlorophenol	2,6-Dimethylmorpholine	$C_{13}H_{16}NO_2Cl_3$	124-5

[a]All compounds listed are mono-Mannich derivatives with exception of number one which is a di-Mannich derivative of 4-bromophenol. [b]Crystals of this compound appear to be slightly solvated.

Table V. Analytical Data for Mannich Derivatives of Cyclic Secondary Amines with Halogenated Phenols

Compound Number[a]	Equivalent Weight		Per Cent Nitrogen	
	Calc'd.	Found	Calc'd	Found
1	213.7	217.4	6.55	6.42
2	311.9	312.6	4.49	4.56
3	163.4	164.1	8.56	8.86
4	295.7	296.8	4.74	4.90
5			4.94	4.67
6	290.8	303.5	4.83	5.00
7			4.83	5.03
8	324.6	324.0	48.09; 4.97[b]	48.32; 5.13[b]

[a]Numbers refer to compounds described in previous Table (IV).
[b]These values refer to analytical results for carbon and hydrogen respectively.

solidified after some 10 to 20 minutes. Fresh water was added after decantation and the mixture allowed to stand overnight. Recrystallization of the crude solid was accomplished from a 70% methanol-water solution. The melting point range of the purified free base was 102.5-103.5°C. and was very sharp. 7.3 g. of the compound represented a theoretical yield of 71% (see Table III for analytical data).

Preparation of a Di-Mannich Derivative: Only one di-Mannich derivative in this group of compounds was prepared, i.e. 4-bromo-2,6-di(2,6-dimethylmorpholinomethyl)phenol. Most mono-Mannich compounds from 4-bromophenol are difficult to isolate as free bases in the solid state (1). We succeeded in preparing a di-Mannich derivative of this phenol, using 2,6-dimethylmorpholine as the secondary amine. A mixture of 17.3 g. (0.1 mole) of 4-bromophenol, 25.7 g (0.22 mole) of 2,6-dimethylmorpholine, ond 75 ml. of 95% ethanol was cooled in an ice bath in the usual manner. 19.8 g. (0.22 mole) of aqueous formaldehyde (35-40%) was slowly added over a 15-minute period, and the mixture was allowed to stand at room temperature for at least one hour. A condenser was then attached to the flask and contents allowed to reflux for at least 10 hours. The volume of the mixture was reduced to one-half the original volume by use of an aspirator, and the residual liquid diluted with a moderate amount of pure emthanol until the solution was clear. Water was then slowly added to the slightly warmed mixture until turbidity appeared, and contents were placed in a freezer to induce crystallization. After solid appeared it was recrystallized from 70 to 80% methanol-water as in the previous example above. The product had a satisfactory melting point at 128.5-130°C. and weighed 10.3 g. This represented a theoretical yield of some 25%. (Analytical data are listed in Table III).

Analytical Procedures: Equivalent weight determinations were made by employing a method siimlar to that outlined by Seaman and Allen.[6] This volumetric procedure utilizing glacial acetic acid as a nonaqueous solvent utilizes 0.1 N perchloric acid with crystal violet as the indicator. The endpoint was verified potentiometrically and observed to be accurate.

Nitrogen determinations were made by a modification of the Kjeldahl procedure of McKenzie and Wallace.[7] The amount of reagent used was altered to allow use of samples weighing 80 to 200 mg.; a solution of mercuric oxide in dilute sulfuric served as an effective promoter. The liberated ammonia was titrated with 0.07 N sulfamic acid to the methyl orange endpoint. Prior to running nitrogen determinations on new compounds, the modified technique was verified by using known compounds. Results are shown in Table II.

All carbon and hydrogen determinations, as well as some Dumas nitrogen results given in Table III, were furnished by Weiler and Strauss Microanalytical Laboratory, Oxford, England.

Summary

The preparation of halogenated phenols containing tertiary aminomethyl groups led to the observation that some possess physiological activity as bronchial dialators with antihistamine properties. Additional compounds having similar structures are reported here. Included also are halogenated phenols contaning secondary aminomethyl groups which were obtained by the use of primary amines.

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HELP! FROM THE IBM 7040 — A STATISTICAL STUDY OF BACTERIOLOGICAL DATA

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Introduction

In order to study the physiology of the aerobic actinomycetes, Redmon (1964), secured values on the oxygen uptake of suspensions of resting cells. This oxygen uptake was measured in a Warburg manometer using the technique described by Umbreit (1957). In 1965, a statistical analysis of the oxygen uptake values was made, using the IBM 7040 electronic computer.

Materials and Methods

Redmon used fifteen cultures obtained from laboratories in Mexico, Alabama, Kentucky, North Carolina, and Tennessee. Some had been isolated from living patients, some at autopsy. The origin of a few strains is unknown. Cell suspensions were prepared from each culture of actinomycete, grown in a medium (pH 6.8) consisting of 2% casitone, 1% glucose, 0.2% KH_2PO_4, and 0.01% $MgSO_4$. When a pellicle had formed on the surface of the broth, the liquid was aspirated and the growth was transferred aseptically to 22 x 175 mm sterile test tubes and centrifuged. The sedimented cells were washed with 15 ml of sterile phosphate buffer (pH 6.8). This was repeated three times, and the final sediment was suspended in 15 ml of the buffer. To determine the oxygen uptake for each culture fifteen Warburg flasks were used. Three flasks for the endogenous respiration, each with 2.0 ml of phosphate buffer, three with 1.5 ml of phosphate buffer in the flask and 0.5 ml of 0.15 *M* glucose in the side arm. The remaining sets of three flasks had 1.5 ml of phosphate buffer and the side arms of the first set had 0.5 ml of 0.15 *M* maltose, the second set similar amounts of lactose, and the third set sucrose. The center well of the Warburg flask contained 0.2 ml of 10% KOH to absorb CO_2. One ml of cell suspension was added to each flask. The flask was attached to the manometer and placed in a constant temperature water bath at 30 C. After five minutes of shaking, the flask was adjusted and tightened, the system was checked for leaks. The stockcock was opened and the substrate tipped in, the reference point of the closed arm of the manometer was set at 250 mm. The stopcock was closed immediately and readings were taken at 15, 30, 45, and 60 minutes by adjusting the fluid level in the closed arm to 250 mm. To convert the mm value of the difference in the readings of the open arm of the manometer to microliters of oxygen uptake at standard temperature and pressure, the mm value was multiplied by the flask constant for oxygen. After the 60 minute reading of the oxygen uptake, the dry weight of the cells in each flask was determined and the values for each culture for each observation period recorded as microliters of oxygen uptake per mg dry cells. Aseptic technique was used throughout so that no rapidly growing contaminant could interfere with the experiment.

The data were analyzed with the IBM 7040.

Results and Discussion

The values for the endogenous oxygen uptake of the resting cell suspensions were unexpectedly high, and ranged from 4.9 to 28 microliters per hour. The addition of glucose resulted in a marked increase in the oxygen uptake, the addition of maltose, lactose or sucrose did not. There were wide variations in the oxygen uptake in some of the triplicate Warburg tests.

Are these variations in values for oxygen uptake great enough to cast serious doubt on the statement "addition of glucose resulted in a marked increase in the oxygen uptake?" If the statement is true, the values for the endogenous Qo_2 must represent a group, and the values for glucose Qo_2 a different group. If the statement is false, the values for the endogenous Qo_2 and the values for glucose Qo_2 represent a single group.

Statistically, this is the evaluation of two arithmetic means.

The arithmetic mean is commonly used as a measure of a group of related values. Obviously the greater the difference between individual values, the less likelihood exists that the mean can be used in place of the complete list of values. Were one to depend on the arithmetic mean solely, it would be possible to decide, erroneously, that the data collected by sampling a single group with widely separated individual values had really come from two different groups.

The standard deviation (1) has been used to avoid this error, but here it is possible to decide, erroneously, that data collected by sampling two groups of individual values had really come from a single group.

$$(1) \qquad SD = \sqrt{\ } \left(\Sigma (\overline{X} - X)^2 \right) / (N - 1)$$

where SD is the sample standard deviation, $\overline{X}$ is the group mean, X is the individual value, and N is the number of individual values.

Is there a method for testing data and at the same time avoiding these two errors? With our particular problem, can we determine whether or not the difference between the arithmetic means of endogenous respiration and of glucose respiration is large enough to justify the belief that the samples from each came from two different groups?

There is such a procedure and fortunately it is included in a standard library program at the University of Kentucky Computing Center (Zerof *et al.* 1965). This has been prepared so that for ". . . uncorrelated comparisons a test to determine the homogeneity of the variances of the variables is made. . . ."

The term 'variance' means the square of the standard deviation, but what shall be chosen for 'variable'? There are fifteen strains of microorganisms, there are four different observation times, and there are five conditions to which the resting cells were subjected; (1) no added sugar, (2) glucose added, (3), (4), (5) maltose, lactose, and sucrose respectively. To the biologists these five conditions, under which the resting cells were studied, represent the most important factors in the experiment. To our advisors in the computing center the fifteen different cultures or the four observation periods seemed just as important. In order to use the computer facilities, the experimenter must decide which is the proper 'variable' and the experimenter must learn enough of the computer vocabulary to communicate his selection to a machine. In this selection the personnel at the center were most helpful.

The values for the 60 minute time period were selected for processing because the Qo_2 is defined as microliters of oxygen uptake per milligran dry weight per hour. Data cards were prepared by punching the Qo_2 values for endogenous, glucose, maltose, lactose, and sucrose. Three cards were required for the triplicate experiment for one actinomycete culture. Forty-five cards represented the data for fifteen cultures.

The library program that was recommended to us is entitled 'T TEST'. Our data cards were processed by the computer with this ready made program. The machine talked to itself for .02 hour and then printed for each 'variable', the sum of the values, the arithmetic mean, the sum of the standard deviations squared, the variance, the standard deviation, the standard error, the coefficient of variation, and the number of observations. These are all calculated from and apply to observations on members of a single group, and although they do not help us to answer the basic questions, certain of these values are used in the computation of the 'T RATIO' and the "T PROBABILITY' which do help us.

It is our hypothesis that the values which we are attempting to assess, follow a normal distribution. In the early days of statistical analysis, it was thought necessary to collect an almost infinite number of values for the construction of a reliable 'curve'. In 1908, William Seely Gossett (1876-1947), a statistician for the Guiness brewery, secured permission to publish a mathematical article. (On the probable error of a correlation coefficient. Biometrica, VI, 302). He signed the article 'Student', and because the 't' distribution which he computed allows the evaluation of small samples, his formula has been of great use to statisticians.

This 't' distribution has been so useful that tables have long been available to find the 't' probability for a given value for $(N-1)$ and, by substituting T RATIO for 't' and $((N_i+N_j)-2)$ for $(N-1)$, to find the T PROBABILITY. However it is futile for a human being to use these tables when the machine performs the calculations so much more rapidly.

(2) $$\text{T RATIO} = (\overline{X}_i - \overline{X}_j) \,/\, S_{ED}$$

where $\overline{X}$ is the sample mean, 'i' is one group 'j' is another group (e.g. endogenous, glucose), and S_{ED} is the standard error of difference (3).

(3) $$S_{ED} = \sqrt{\ } \,(Var_i / N_i) + (Var_j / N_j)$$

where Var is the variance (4) and N the number of samples in the group.

(4) $$Var = (N_i \Sigma X_i^2 - (\Sigma X_i)^2) \,/\, N_i\,(N_i - 1)$$

where X is an individual value and N the number of individuals in the sample.

It is important to note that 't' and 't' probability refer to the question, "Does this individual belong to this one group?" T RATIO and T PROBABILITY refer to the question, "Do these two means belong to the same group?" The higher value of either 't' probability or T PROBABILITY, the greater the certainty that a single group is involved; conversely the lower the value, the greater the certainty that more than one group is involved.

Table 1 shows the values computed by the machine for all combinations of the five conditions; endogenous, glucose, maltose, lactose, and sucrose.

The values listed in this table (Table 1) show that there is no possibility that the endogenous respiration represents a group that has any relation to a group exposed to glucose as substrate. Furthermore, glucose treated cells and maltose treated cells constitute different groups, as do the glucose and lactose treated cells, and likewise the glucose treated and sucrose treated cells. We must make this conclusion because the T PROBABILITY for each of the above combinations is 0.000. . . .

It can be noted that endogenous and maltose groups, as well as maltose versus lactose treated groups have a T PROBABILITY of 0.027 and 0.026 respectively. For a two tailed hypothesis this would be 0.054 and 0.052. These are low values and indicate that the respective groups are different, because in about 5% of the samples from a single group a value as large as –1.95 or 1.97 (T RATIO) would be obtained. On the other hand, the endogenous and lactose treated groups show a T PROBABILITY of 0.338 (for two tailed 0.676) and this high value indicates that the two means are from a single group because in 67% of the samples from a single group a value equal to or larger than –0.42 (T RATIO) would be obtained.

Table 1. Report of the IBM 7040

Condition	T RATIO	DF	T PROBABILITY*
Endogenous vs. Glucose	–6.04	62	0.000
Endogenous vs. Maltose	–1.95	88	0.027
Endogenous vs. Lactose	–0.42	69	0.338
Endogenous vs. Sucrose	–0.86	87	0.197
Glucose vs. Maltose	4.88	61	0.000
Glucose vs. Lactose	6.23	49	0.000
Glucose vs. Sucrose	5.67	57	0.000
Maltose vs. Lactose	1.97	71	0.026
Maltose vs. Sucrose	1.31	87	0.114
Lactose vs. Sucrose	–0.62	73	0.268

* For two tailed hypothesis multiply the T PROBABILITY by two.
DF is degree of freedom.

Summary

The speed with which calculations on raw data can be made, provided that the correct program has been fitted to the computer, afford the experimenter an opportunity to formulate different hypotheses and to test their validity very quickly. It is thus, par excellence, a tool for the training of a student in analytical thinking whatever may be his field of endeavor.

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A RARE IRON CONGLOMERATE OCCURRING IN NORTHEASTERN HARDIN COUNTY, KENTUCKY

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While engaged in an oil and gas reconnaissance of the geology of a portion of the valley of the Rolling Fork of Salt River lying from 1 to 3 miles southwest of the village of Boston in western Nelson and eastern Hardin County, Kentucky, on December 9, 1958, the writer inadvertently discovered a rare type of iron cemented pebble-stone[1] in the channel of a steep intermittent hillside branch. Representative samples were collected and subsequently given to the Kentucky Historical Society to be added to the rapidly growing rock collection of this organization seated in the old State House in Frankfort. Intrigued time and again during the flight of the succeeding years by recollections of this unique, heavy brown iron conglomerate, a return to the locality of its discovery in eastern Hardin was made on October 1, 1965. The significant results of this examination follow.

The iron conglomerate, of 1958 record, was quickly found to be entirely disconnected stratigraphically with any part of the New Providence (Lower Mississippian) formation which outcrops there at the base of the first Muldraugh Hill in a thickness of about 50 feet. The pebble-stone occurs as a very limited fluvial deposit in a sharply etched, roughly circular erosional basin about 3.5 feet in diameter, some 15 to 18 feet below an intermittent falls of upper hillside branch water. The course of this small stream leaves a normal shallow drain in brush and cull timber and debouches over the south face of a deep wood cut in the New Providence Shale into which it has eroded a shallow channel of very steep angle to the aforesaid circular basin, below which the stream at a greatly lowered angle finds its way to the south ditch of Highway No. 62, thence on to the broad flat bottoms of the Salt River.

The pebbles found in this iron conglomerate, with one exception, are all slightly stream washed from nearby residual rock waste occurring at levels 80 to 125 feet higher in the New Providence and the formerly overlying Keokuk (Lower Mississippian) formation. Cherts of various types, brown and light tan to chalky white, both solid and porous, angular and subangular, predominate. But fine to medium sand pebbles, some oval flat, others rounded, also occur in this fluvial

1. Author's field *Note Book* "AA", p. 25, No. 38. Dec. 9, 1958; also Book "HH", pp. 3-4. No. 10. Oct. 1, 1965.

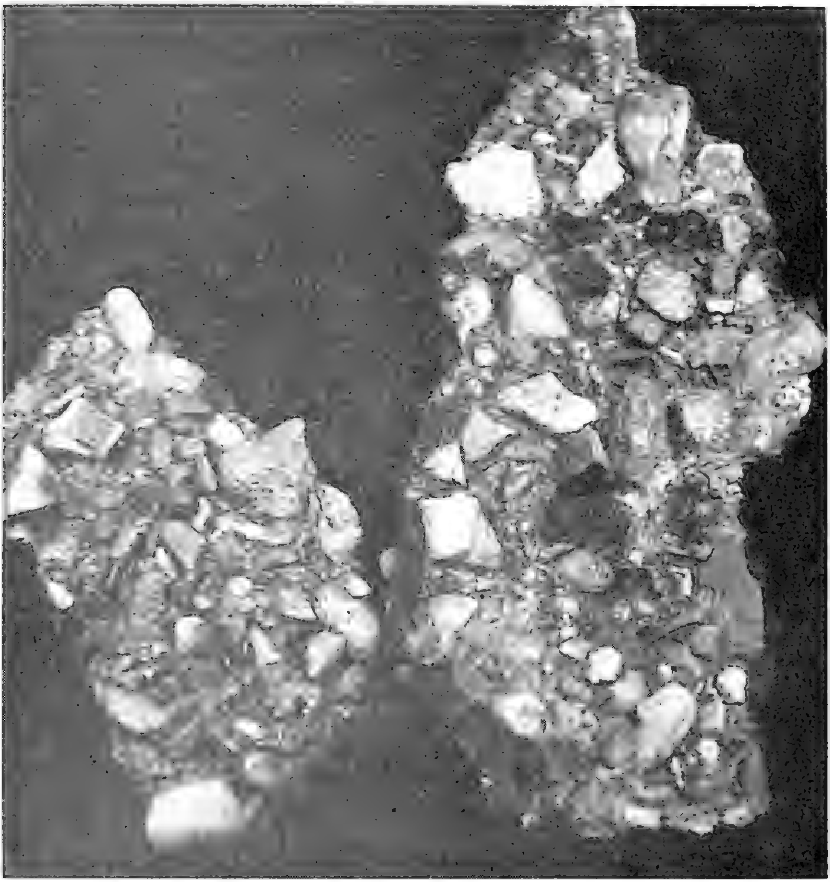

Figure 1—Iron Conglomerate from Hardin County, Kentucky. The length of the larger specimen is 14 inches, the smaller one 9.5 inches. The pebbles comprising these conglomerate fragments are here, accordingly, greatly reduced in size.

conglomerate. Occasionally a solid white or tan quartz Pottsville (Lower Pennsylvanian) pebble is noted, derived from remnant patches of hilltop fluviatile gravels deposited during the late Miocene or early Pliocene epochs of the Tertiary in the shallow, meandering, long abandoned channels or on the lower parts of the flood plain of the ancient high level Rolling Fork River. The pebbles, thus variously sourced, and of widely differing lithology, range in size, when elongate from 1 to 2.5 inches and when rounded or oval from .5 to 1.5 inches.

Of fossils, large or small, there is a very great scarcity, in fact, none have been noted except a very few short three or four plate crinoid or blastoid stem sections exhibiting diameters ranging from 1.5

to 2 tenths of an inch. The genera, much less the species of these wandering organic fragments, are of course entirely indeterminate. One or two Pottsville quartz pebbles, of medium to small size have been noted in each specimen of this conglomerate, generally rather deeply imbedded in the dark brown to black central iron stone matrix, which is very solid and frequently quite brittle. Its thickness ranges from .5 to 1.25 inches usually, but one or two specimens have been seen where the central iron layer exhibited a thickness of from 1.50 to a full 2 inches. This greater thickness, however, is quite exceptional.

The pebbles, occurring in this conglomerate, accordingly are in many instances exposed, of course, only partially, usually to an extent of about ¼ to ⅝ of their thickness or their entire mass, either at the top or the bottom of this extraordinary agglomerated rock. Chemical analyses of the iron ore matrix of this particular conglomerate, desirable as they might be as an accessory description, have not been made as this facility has not been immediately available to the writer, but based upon experience is here quantitatively estimated to be about 40 to 55% FeO with the balance of insolubles showing as SiO_2 and Al_2O_3.

An interesting angle of speculative thought involving the time element of formation of the rock, attaches to this particular Hardin County conglomerate and so logically appears in this paper, it may be, for the first time in the geological literature of the Ohio Valley, and perhaps, though this is of course less likely, in that of the entire country! All hard rocks require time, some a great deal of time, others much less for their induration. Volcanic lavas cool and harden very rapidly, especially if a thin flow on a steeply inclined mountain side is involved. All geological experience inclines to the view that the induration of the sedimentary beds is a slow, a very slow process involving not only vast stretches of time but also superimposed beds of great weight to bring about compaction. Old and long accepted trends of thought on the induration of sedimentaries must now, it appears, be laid aside with respect to this unique iron conglomerate, found at the base of the first of the Muldraugh Hills west of Salt River in Hardin County, Kentucky, as the following facts clearly indicate.

Thoroughly dependable records show that the grading and ditching of *the deep cut in the first low hill* on State Highway No. 62, west of the Salt River in eastern Hardin County, was completed and approved, following inspection, on June 24, 1925.[2] Erosion of the shallow, high angle channel of the "waterfall branch" across the upper part of

2. Letter to the author from D. M. Burgess, Director of Planning of the Kentucky State Dept. of Highways, Frankfort, Ky. Oct. 6, 1965.

the exposure of the New Providence Shale in this particular cut on the south side of Highway No. 62, some 2400 to 2500 feet southwest of the Salt River in Hardin County, began then or very shortly after this date in the mid-year of 1925. The small basin, in which the iron conglomerate was formed and is now found, was obviously formed during the first 5 or 10 years after 1925, before the ledge of rock producing the falls had receded some 15 or 20 feet to the position it now occupies.

At the present time and probably for a good many years branch water here has not fallen directly into the circular basin, but after leaving the "Falls Ledge" has cascaded down a steep shallow channel in the New Providence and passed on and over the old "Falls Basin" in a deepening, rock-cut channel to the south ditch of Highway No. 62. Close inspection of the lower part of the "Falls Branch" channel, indicates that the "Falls Basin" is now probably not nearly as deep as it once was, before the recession of the "Falls Ledge" and that for a good many years it has been simply a deep place in the otherwise shallow, highly tilted channel of the wet-weather "Falls Branch".

The mass of variegated, insoluble chert and sandstone pebbles which the Falls Branch gathered in the hills above and used as tools to cut the circular basin in the lightly resisting New Providence shale, remained in the bowl-like depression after the Falls had receded, perhaps rather abruptly following the fall of some ledge blocks, as frequently happens to all water falls. The small and more or less intermittent flow of iron-bearing waters leached from hilltop and upper channel beds, obviously sustained considerable evaporation at the Falls. As the upper water found its way, in dry periods, downwardly over innumerable ledges in the steep channel it was somewhat increased by subsurface waters issuing from beds of disseminated iron ore, sizeable kidneys and lenticles that plainly show here in the exposed stratigraphic section. These combined branch waters, tending with constant and rapidly increasing evaporation to greater and greater concentration of iron in solution, were collected and held in the fairly deep pebble-filled basin. In periods of extreme and extended dryness, as their volume shrank, and ceased its flow, as was the case at each period of examination, the iron content of these dwindling branch waters was precipitated in amongst and around the insoluble pebbles in the abandoned stream bed basin below the several iron ore horizons of the New Providence Shale.

The erosive action of intermittent streams of small flow has long been established as very slow. All physical factors and changing the circumstances of drainage apparently did not combine to increase concentration and bring about precipitation of the iron in the branch water as a matrix solidifying all or most all of the gravels in the branch basin for probably at least 15 years—or until about 1940. The growth of the iron conglomerate found in this "Falls Branch" basin may therefore be said, with some degree of dependability, to have been accomplished within the last 25 years. This timing, it is thought, may be used with some assurance of accuracy in arriving at the time element required for the filling of veins and crevices in the bedded rocks of mineralized areas by downward percolating iron-bearing aqueous solutions.

LINGULA NODULARATA, SP. NOV., OCCURRING IN POWELL COUNTY, KENTUCKY

WILLARD ROUSE JILLSON
Frankfort, Kentucky

While engaged in executing a field study of oil and gas structure in the vicinity of Stanton[1] in central Powell County, Kentucky, on July 31, 1963,[2] the writer's attention was caught by the occurrence of a well defined, locally-continuing strata of small, brownish, clay-stone nodules in a ten-foot, slightly weathered exposure of the Cuyahoga (New Providence) shale outcropping on the west side of the Cat Creek road, about 1500 feet south of State Highway No. 15 and lying adjacent to the land of Grace Knox. Stopping briefly, two of these nodules, each quite noticeably spherical in figure, were collected from their original place of outcrop, sacked, labeled and dated. Returning to Farnkfort toward the end of the day, these two nodules were numbered for prospective study. No. 1 nodule upon being split open by the blow of a hammer, exhibited a measured diameter of .7 of an inch; No. 2, when similarly opened, showed a diameter of .8 of an inch.

Upon close examination with a hand lens, each of the nodules revealed a single, very small, glossy, dark brown to black, well preserved bi-valve. Unable to recall from memory the exact species of this minute fossil, about which as a central bit of organic life the nodule in each case had very evidently grown, the writer sent them to Dr. G. Arthur Cooper, a widely recognized invertebrate paleontologist and a long time friend, in the Smithsonian Institution at Washington, D. C., requesting, if possible, identification of both genera and species. Shortly thereafter a letter was received by the writer from Dr. Cooper, stating that the specimens were without doubt LINGULAS, but of a species unmatchable in the collections of the Smithsonian Institution.[3] Return of the fossil specimens—No. 1 and No. 2—closely followed the letter.

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1. *Geology of the Area about Stanton, Powell County, Kentucky,* 33 pp. Illust. Map. Pamph. by Willard Rouse Jillson, Roberts Printing Co., Frankfort, Ky. December 2, 1963.
2. Author's Field *Note Book "FF." Lingula* discovery and later field work. Pp. 115, 125 and 131, July 31, Aug. 13 and 20, 1963.
3. Official correspondence. A letter from Dr. G. A. Cooper, Head Curator, Dept. of Geology, U. S. National Museum, Washington, D. C. to the author, dated Sept. 9, 1963.

Upon receipt of this advice, the writer immediately returned to the type *Lingula* locality on Cat Creek in Powell County and by close and careful work increased his collection to about 35 unbroken nodules of siimlar size and appearance, and all from the same horizon and outcrop as the two original specimens. At this time, A. T. elevations of 700 feet at the bottom and 710 feet at the top were placed by barometer on the roadside exposure of the New Providence Shale that exhibited the Lingula nodular horizon, which was found by checked barometer to be 50 feet above the top of the black New Albany (Upper Devonian) Shale. Subsequent collections in this area, made with increasing difficulty have enlarged the entire collection of nodules derived from this horizon on Cat Creek to about 50. All the nodules in the collection have been carefully split open and examined. Out of the entire collection of nodules upwards of a dozen specimens of the same little, black, shiny brachiopods were recovered. The fossilized nodules were therefore about 1 in 4 or 5 in the entire nodular assemblage.

Figure 1.—Clay-stone nodules containing *Lingula nodularata* sp. nov. fossils.

The specimen *Lingulas,* measured in their separate nodules, exhibit a range in length of from 1.5 to 3.5 tenths of an inch, and in width from 1. to 2.5 tenths of an inch. These Cat Creek nodular *Lingulas* have been compared by the writer with the published figures of several other *Lingulas* occurring in the Lower Mississippian beds, chiefly in Ohio, and while similar, of course in many respects, particularly to *L. Melia* found in the Chagrin Shale of that state, these recently discovered Powell County forms have been clearly recognized to have much

Figure 2.—*Lingula nodularata* sp. nov. width of specimen is 0.2 inch.

finer and more even growth lines than any now described in the pertinent paleontological literature[4] as found in the collections of the U. S. National Museum in Washington, D. C. Accordingly, the writer recognizes these tiny Cat Creek brachiopods as a new and hitherto undescribed species of *Lingula* and to them he here gives the name *Lingula nodularata.*

In closing this briefly descriptive announcement touching upon *Lingula nodularata,* sp. nov., the writer desires to extend sincere thanks and no little admiration to a long admired friend, Dr. Roger W. Barbour of the Department of Zoology of the University of Kentucky[4] to whom he and all those who take interest in the advent of this new member of the rather extensive family of darkfaced *Lingulas* for the production of the marvelous photo-magnifications he made of the type specimens of *L. nodularata* to accompany this paper introducing this tiny but important *species nov.* And finally the writer's entire collection of *Lingula nodularata,* together with the residual suit of broken nodules has been given to the Smithsonian Institution to insure their proper preservation and for the use of future workers in this late Paleozoic invertebrate field whenever in the years to come they appear and whoever they may be.

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4. The following publications have been examined in the course of preparing for the writing of this paper. I. G. H. Girty, P.P. No. 193-C, pp. 47-67. U. S. Geol. Survey, Washington, D. C. 1939. II. C. L. Herrick, Vol. IV, P. I & II, Bull. Dennison Univ., 1898. III. Shiver and Shrock. *Index Foss'ls of N. Am.* 837 pp. N. Y. C. 1944. IV. A. Foerste, *The Bedford Fauna at Indian Fields and Irvine, Ky.* Pp. 515-23. The Ohio Naturalist, Vol. IX. No. 7, May, 1909. V. James Hall, *New Species of Brachiopods.* Pal. of N. Y. Vol. VIII. Parts 1 and 2. Albany, N. Y. 1892-1894.

A LIMESTONE CONGLOMERATE OCCURRING IN THE EDEN OF CLARK COUNTY, KENTUCKY

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During the latter part of the morning of September 13, 1963, while checking outcrops of Cynthiana and Eden limestones recently trenched by low rock cuts along the new super-highway I-64, northeast of the *Winchester Disturbance,*[1] in northeastern central Clark County, Kentucky, the writer made discovery of a thin but prominent limestone conglomerate. Of unusual lithological character, unknown extent and unrecorded, it is believed, in the pertinent geological literature of Kentucky. Its occurrence coupled with its rather high position on the eastern flank of the Cincinnati Arch, bespeaks for it some passing notice, if only, as it must be at this time, of a preliminary nature. Brief additional studies of this exposure, including rock and fossil collections on both sides of the expressway and stratigraphic sections were made on September 21, 1963 and an overall review of the entire exposure including additional rock and fossil collections, preliminary to the writing of this paper was made on October 9, 1965.[2]

The exposure in which this unique conglomeratic limestone occurs is to be seen at a point about 8000 feet northeast of the U. S. Highway overpass at a crushed rock "crossover" on the north side of the north (west-bound) lane of expressway I-64. Topographically this outcrop is on the upper northern slope of a ridge forming the southern headwaters divide of Cabin Creek, a northeasterly flowing tributary of Stoner Creek. The conglomeratic lime occurs at an altitude of 1017 feet A. T., Bar. For further surface detail, if desired, the reader is referred to the recent Austerlitz quadrangle.[3]

The conglomerate limestone of central note in this paper ranges from 2.5 to 6 inches in thickness. It exhibits a very hard and thoroughly indurated gray crystalline ($CaCO_3$) matrix into which are imbedded a great many subangular to angular calcareous pebbles, rock and fossil fragments ranging in length from .6 to 2.2 inches; in width from .3 to 1 inch and in thickness (as exposed) from .3 to .65 of an inch. Fossils found in or attached to the calcareous matrix of this conglomerate

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1. *Geology of the Winchester Disturbance.* 24 pp. 8 photos. Map. Pamph. by Willard Rouse Jillson. Roberts Printing Co. Frankfort, Ky. November 6, 1963.
2. Author's field *Note Book "FF"*, pp. 132, 140, 141 and 143. Sept. 13, and 21, 1963; and *Note Book "HH"*, pp. 6, October 9, 1965.
3. *Austerlitz Quadrangle.* Anonymous. Colors. Scale: 1-24,000. Ten foot contours. U. S. Geol. Surv., Washington, D. C. 1959 See S E. quadrant.

Figure 1.—Limestone conglomerate from the Eden of Clark County, Kentucky.

were: *Dalmanella emacerata, Dalmanella multisecta, Dekayella ulrichi, Hallopora onealli, Ectenocrinus grandis, Aspidopora eccentrica* and *Plectambonites rugosus,* a dependable Eden assemblage, but certainly not an abundant one!

This group of well known forms suggests middle Eden, but as this seems quite unlikely, further field work here is indicated as important. Unfortunately, however, there appears to be no immediately observable continuance of this distinctive pebble-stone due to the local vagaries of erosion and topography. Although they appear, so far as examined, to contain no fossils, the pebbles and rock fragments of this conglomerate are assumed to have been derived from Upper Cynthiana beds (Upper Middle Ordovician) at no very great distance. Cynthiana (Rogers Gap) limes dipping 2°-3° to the southwest underlie this Eden conglomerate which cuts diagonally across them in its 1°-2° dip N. 80° E. The entire exposure here is about 250 feet long and not more than 10 feet high from the expressway ditch to grasslands and fence line above.

The gray limestones and limey shales immediately underlying the thin Eden conglomerate of principal interest in this paper, were carefully examined and from them on both sides of I-64, at the crushed rock "crossover", the following Rogers Gap and Greendale (Cynthiana-upper Trenton) fossils were collected and identified by the writer on September 21, 1963. Those marked by asterisks are regarded as reliably characteristic forms.

List

I CYNTHIANA

Rogers Gap

1. *Strophomena halli**
2. *Clitambonites rogersensis**
3. *Bellerophon rogersensis**
4. *Eridorthis rogersensis**
5. *Eridorthis nicklesi**

Greendale

1. *Cyclonema varicosum**
2. *Triarthus becki*
3. *Rafinesquina alternata*
4. *Rafinesquina winchesterensis**
5. *Lophospira bowdeni*
6. *Orthoceras duseri*
7. *Herbertella occidentalis**

8. *Herbertella subjugata**
9. *Echarspora maculata**
10. *Constellaria fischeri**
11. *Eridotrypa briareus**
12. *Homotrypa norwoodi**
13. *Prospora falesi*
14. *Zygospira modesta*

FISH COPROLITES IN THE ONONDAGA LIMESTONE OF EASTERN CENTRAL KENTUCKY

By WILLARD ROUSE JILLSON

Having read with much interest during the early 1920's Professor William M. Linney's late Nineteenth Century brief but important notation of the occurrence of a broad scattering of piscene osteological remains in the basal layer of the Onondaga (Middle Devonian) limestone in northwestern Powell County, Kentucky,[1] the writer found much pleasure in making similar discoveries in the bottom bed (Kiddville) of the same formation on the upepr waters of Arbuckle Creek in southern Marion County on April 17, 1952.[2] These recent mid-Kentucky piscene findings, heretofore unrecorded in the literature, were set out in some useful detail in pamphlet form later in the same year.[3]

Continuing these piscene investigations on September 14, 1952, a fine, bright autumnal day, the writer guided by a friend of many years standing, the late much lamented, Col. Lucien Beckner of Louisville, a native and many years a resident of Winchester, Kentucky, executed with great care a field reconnaissance of the identical area in northwestern Powell County in which Linney had found much fish bone material nearly 70 years previously.[4] The exact location on the head of Hensley Branch of Lulbegrud where the *Machaeracanthus* spine, now in the Louisville Museum, was found by John William McIntosh (B. 1874-D. 1953) in the Summer of 1932, was visited, as was the locality on Copperas Creek near the site of Eastin's old mill, where old Professor Linney, some 80 years ago found in the lower part of the New Albany black shale "two large dorsomedian plates." These he, in 1884,[5] and Professor John Strong Newberry in 1889[6] referred to probably an undescribed species of the terrible upper Devonian shark (?) *Dinichthys,* a mid-Paleozoic marine Placoderm of gigantic proportions, probably 20 to 25 feet in length and 15 to 18 feet in belly girth.

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1. *Report on the Geology of Clark County,* 43 pp. Geol. Surv. of Ky. (Proctor) (Frankfort, Ky.) Pages 29-30. 1884.
2. Author's field *Note Book "P"*. Pp. 55, 56, 57, 59, 61, 62 and 63. 1952.
3. *The Bone Bed Sandstone.* 244 pp. Illust. Pamph. By Willard Rouse Jillson. Roberts Printing Co., Frankfort, Ky. Sept. 25, 1952.
4. Author's field *Note Book "P"*, Pp. 119, 121, 126 & 127. 1952.
5. *Report on the Geology of Clark County.* Linney. Page 34.
6. *The Paleozoic Fishes of North America.* J. S. Newberry. Vol. XVI, U. S. Geol. Surv., Washington, D. C. Page 59.

Figure 1.—Fish coprolites from the Onondaga limestone of Eastern Central Kentucky. Length 13 inches.

Following these examinations which turned up (on Hensley Branch) only one coprolitic sandy limestone slap worthy of collection, the writer returned to the area of Fall exposure of the Onondaga (Corniferous or Boyle) limestone which borders Highway No. 15 on the northeast side at a point 1000 feet south of the vehicular bridge over Lulbegrud Creek and a little beyond the intersection of the old, original and now abandoned road to West Bend and Clay City in northwestern

Powell County. At this locality two large and excellent coprolitic slabs of the sandy lime, 8 inch Kiddville layer, fallen from the lower part of the Corniferous were found and collected[7] for further study.

These two specimens coupled with the one found previously on Hensley's Branch constitute the three coprolitic slabs featured and illustrated in this paper. These three flat Kiddville rocks exhibit the following dimensions. A. 6.5 x 12 x 2.4 inches; B. 9.7 x 13 x 2.8 inches and C. 9 x 5.5 x 2.4 inches. Their approximate bulk follows. A. 450 cubic inches; B. 350 cubic inches and C. 125 cubic inches. Bone plate coprolites on these three Kiddville slabs averaged, length 1.63 inches; width 1.05 inches; and thickness .375 inches. Indeterminate coprolitic boney fragments averaged, length 1.76 inches; width 1.03 inches and thickness .60 inches. The measurements of these two groups combined are: Length 1.69 inches; width 1.04 inches and thickness .462 inches. The average Middle Devonian (Kiddville layer) rounded or subangular lump of piscene boney excretia found in the vicinity of the vehicular bridge on Highway No. 15 in Powell and Clark Counties is thus seen to be about the size of my lady's rouge box "*in purse.*"

The approximate contents of each of these three Kiddville slabs follows. A. 450 cubic inches; B. 350 cubic inches and C. 125 cubic inches. These three slabs exhibit at the surface a total of 75 large and small bony coprolites and it is probable that as many as 25 more are entirely encased within the three rocks. If this rate of coprolitic accumulation on and in the Kiddville sandy-lime during early Onondaga-Coorniferous (Middle Devonian) time held constant for any considerable area, the number of coprolitic fragments deposited during mid-Paleozoic time in the vicinity of the vehicular bridge in northwestern Powell and southeastern Clark Counties would have been in excess of 11,000,000 boney units of piscene excretia to the square mile. Surely this is not an inconsiderable addition to normal marine sedimentary accumulation anywhere. In finale, it may not be improper to state that this paper is thought to be the first piece of writing devoted entirely, as its title indicates, to Paleozoic coprolites, to appear in either the geological or the paleontological literature of Kentucky.

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7. Author's field *Note Book "P"*, page 127. Sept. 23, 1952.

A PRELIMINARY LIST OF THE MAMMALS OF ROBINSON FOREST, BREATHITT COUNTY, KENTUCKY

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Robinson Forest is a tract of approximately 13,000 acres of mixed mesophytic woodland situated in the drainage of Buckhorn Creek, in the vicinity of Noble, Breathitt County, Kentucky. Almost the whole of Cole's and Clemon's Forks, tributary to Buckhorn, are within the forest. Robinson Forest is owned by the University of Kentucky, and is administered by the Department of Forestry of the College of Agriculture.

In the 1930's a set of well constructed rustic log buildings were started along the lower reaches of Clemon's Fork, under the auspices of the National Youth Administration. Apparently floors, walls, and roofs only were erected at that time, and the buildings remained unfinished until the early 1950's. At that time the University completed the buildings and furnished them with adequate camp furniture. Since completion, Camp Robinson has been used for a variety of educational purposes. The utilization of the camp has greatly increased human traffic in the area, to the detriment of certain mammals.

Over the past 12 years or so, the vertebrate fauna of Robinson Forest and the immediately surrounding areas has been studied by the senior author, his colleagues, and their students. Lists of fishes (Kuehne, 1962), amphibians and reptiles (Bush, 1959), and birds (Barbour, 1956) have been published.

Hamilton (1930) listed 30 species of mammals from Breathitt County, largely from the vicinity of Quicksand. Barbour (1957) listed *Corynorhinus rafinesquii* from Camp Robinson. This report has been prepared to make our findings to date available.

In 1960 and 1961 the authors spent approximately 10 weeks in Robinson Forest, mostly in summer, and devoted a large portion of that time to a survey of the mammals of the area. In previous and subsequent years the senior author has observed and collected mammals in the area as other duties permitted. All specimens are deposited in the collection of the Zoology Department of the University of Kentucky.

We would like to express our gratitude to all who have assisted in this study; particular thanks are due William Byrd Barkley for his assistance in the summer of 1960.

Annotated List of Species

1. *Didelphis v. virginianus.* Opossum. Opossums have been rare in Robinson forest at least since the beginning of this study in 1955. Our only record is a portion of a recent skeleton from alongside a trail in 1960.

2. *Parascalops breweri.* Hairy-tailed Mole. Tunnels apparently made by this species are commonly encountered in the forest, alongside roads and trails, and in more or less open fields. We have but one specimen, an adult female taken June 23, 1955.

3. *Sorex fumeus fumeus.* Smoky Shrew. We took a single specimen of this species from dense woods at an elevation of 900 feet on April 28, 1961. The animal, a mature female, was lactating from six mammae. This species is currently known from but three other localities in Kentucky: Bailey (1933) took a small series from Mammoth Cave; Welter and Sollberger (1939) took a single specimen from Morehead, Rowan County; and Barbour (1951) recorded 12 specimens from Big Black Mountain in Harlan County.

4. *Blarina brevicauda kirtlandi.* Short-tailed Shrew. This is one of the commonest mammals of the forest, and occurs in habitats ranging from dense woodlands through brushy areas to grassy fields.

5. *Pipistrellus subflavus subflavus.* Eastern Pipistrelle. This is probably the commonest bat of Robinson Forest. Two pregnant females, each with two nearly full term embryos were taken on June 23, 1960. Numerous individuals were observed about that time, and many were obviously pregnant. They could readily be distinguished by their slow, heavy, labored flight. As nearly as we could determine, several individuals spent the days among the foliage of some large sycamores at Camp Robinson. We could never find them at rest, but we normally saw them first in the evening flying about the fairly isolated trees.

6. *Eptesicus fuscus fuscus.* Big Brown Bat. Apparently there are neither maternity colonies nor hibernacula of this species within the forest, so the population is limited to migrating individuals or summering males. Our only specimen is a mature male shot at Camp Robinson on April 27, 1961.

7. *Lasiurus borealis borealis.* Red Bat. This species occurs commonly throughout the forest, and individuals can be seen flying almost any warm evening.

8. *Plecotus refinesquii rafinesquii.* Big-eared Bat. In the early 1950's a maternity colony of approximately 100 individuals of this species occupied the attics of the unfinished buildings at Camp Robinson. In the mid-50's and later, efforts were made to exclude the bats from certain areas, with varying success. Since about 1955 there has been a steady decline in the size of the colony. In 1966 there were probably not over a half dozen adults in the colony. There is some rather half-hearted interest in preserving the colony on the part of the people using the buildings, but we fear that the colony is doomed.

9. *Sylvilagus floridanus mearnsi.* Mearns Cottontail. Cottontails may be frequently encountered in open fields along the major streams, but are rarely encountered in the forest.

10. *Tamias striatus striatus.* Southern Chipmunk. This species is abundant throughout the area, at all elevations. Our series of seven specimens averages much darker, with less red, than a series of *T. s. ohionensis* from Fayette and adjacent counties.

11. *Sciurus carolinensis carolinensis.* Gray Squirrel. Gray squirrels occur throughout the forest, and are by far the most popular small game animal.

12. *Glaucomys volans volans.* Eastern Flying Squirrel. Flying squirrels are common in Robinson Forest, but are rarely seen. Our four specimens came from Camp Robinson; however the arboreal nests and characteristic cuttings can be found throughout the forest.

13. *Peromyscus leucopus noveboracensis.* White-footed Mouse. This is undoubtedly the most abundant rodent in Robinson Forest. It may be found at all elevations, and in essentially all habitats. It commonly enters the camp buildings, where on occasion it is responsible for considerable damage. We took a female which gave birth to four young on May 5, 1961. By June 2, the young had essentially reached adult size, and were perfectly capable of an independent existence.

14. *Ochrotomys nuttalli nuttalli.* Golden Mouse. This species is rare in Robinson Forest, due no doubt to the scarcity of brushy areas which the golden mouse prefers. Our only specimen is an adult from a brush-covered hillside on Buckhorn Creek.

15. *Neotoma magister.* Wood Rat. The relative scarcity of rock outcroppings in Robinson Forest is undoubtedly a limiting factor for this species. We have observed signs of this species about the exposed rocks along the ridge that separates Cole's and Clemon's Fork, but they seem nowhere common. Our only specimen is from a rocky out-

crop in dense woods near Camp Robinson, at an elevation of about 900 feet.

16. *Synaptomys cooperi stonei.* Bog Lemming. This is a common mammal in grassy clearings in the forest, and in the grassy fields along the lower reaches of Buckhorn Creek. A substantial colony inhabits a grassy area on the grounds of Camp Robinson. We collected a series of 21 individuals, two of which were pregnant females. One of these, with 3 embryos, was taken July 14, 1966; the other, with 5 embryos, was taken October 22, 1960.

17. *Pitymys pinetorum auricularis.* Bluegrass Pine Vole. Pine mice occur sparingly throughout the forest, even in deep woods, but are more abundant in the overgrown fields along Buckhorn Creek. A female with two 23 mm. embryos was taken on October 22, 1960.

18. *Ondatra zibethica zibethica.* Muskrat. We took no specimens, but occasionally saw a muskrat along the lower reaches of Buckhorn Creek. In the fall of 1966 fresh tracks and cuttings were observed in Clemon's Fork just across the road from Camp Robinson.

19. *Mus musculus brevirostris.* House Mouse. House mice are rare in are area. Our only specimens (3) came from the lower reaches of Buckhorn Creek.

20. *Mephitis mephitis nigra.* Eastern Skunk. Skunks are rarely encountered. One specimen was collected along Clemon's Fork below Camp Robinson. Another individual was observed foraging about a garbage can at the camp on October 22, 1960.

21. *Urocyon cinereoargenteus cinereoargenteus.* Gray Fox. The gray fox occurs throughout the forest, but they are rarely observed. Their tracks may be frequently encountered along the logging roads. We have no specimens.

22. *Procyon lotor lotor.* Raccoon. This species is apparently scarce in the forest. Their tracks are only rarely encountered along the watercourses. We have no specimens.

23. *Lynx rufus rufus.* Bobcat. Our only record of this species is the sighting of a near-perfect set of footprints left as a large individual crossed a muddy spot in a logging trail in the summer of 1960.

24. *Odocoileus virginianus virginianus.* Virginia Deer. This species was largely, if in fact not completely exterminated in the area by the early 1900's. Restocking and protection were sufficient to build up an excellent herd, both in quality and quantity, by the middle 1950's. Since that time, several seasons of intense hunting pressure, coupled

with poaching, have seriously depleted the herd. In 1966, few signs were evident, but some deer were present in the forest. With care, the herd can be built back to essentially the carrying capacity of the area.

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DIPOLE MOMENTS AND APPARENT MOLAL VOLUMES OF N-CYCLOHEXYLSULFAMIC ACID AND NITROBENZENE IN N,N-DIMETHYLACETAMIDE AND N-METHYL-2-PYRROLIDONE*

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Sulfamic acid ($H_3\overset{+}{N}\text{-}\overset{-}{SO_3}$) is similar to glycine in that it exists in a dipolar ionic or zwitter-ionic form in the solid state (Kanda and King, 1951). In water it ionizes upon dissolution to yield an acidic medium with strength comparable to that of nitric or hydrochloric acid. Sulfamic acid is essentially insoluble or reacts chemically with most organic solvents. In N,N-dimethylacetamide (DMA), N-methyl-2-pyrrolidone (NM2PY), and dimethyl sulfoxide (DMSO), however, it is soluble to the extent of several weight per cent and yields solutions which are practically non-conducting. The dielectric increments, high values for the dipole moment, and very low conductivity of sulfamic acid in these solvents indicate that it retains its dipolar ionic form upon dissolution (Sears, Fortune and Blumenshine, 1966).

N-Cyclohexylsulfamic acid (hereafter abbreviated CHSA) is a non-hygroscopic solid having the formula, $(C_6H_{11})H_2\overset{+}{N}\text{-}\overset{-}{SO_3}$. Also referred to as Hexamic Acid and Cyclamic Acid, it is non-caloric food and beverage additive which uniquely exhibits a sweet-tart taste along with strong acidulant properties (Technical Bulletin No. 355, 1964). Being a derivative of sulfamic acid it is not surprising that the acidic properties of CHSA is aqueous solution closely parallel those of its parent. Exploratory measurements in this Laboratory revealed that CHSA behaves like sulfamic acid in DMA and NM2PY but slowly reacts and becomes more conducting in DMSO.

The principal objectives of the research associated with this paper were to obtain quantitative physico-chemical information for solutions of CHSA in DMA and NM2PY and to make comparisons with corresponding systems containing sulfamic acid. In addition to using dipolar ionic CHSA, nitrobenzene as a typical polar covalent species was used as a solute in the same solvents for parallel measurements and calculations.

Experimental

Solvents. Commercial grade DMA and NM2PY were purified by fractional distillation over calcium oxide at a reduced pressure of

* Taken from a thesis submitted by Terrell W. Holt in partial fulfillment of the requirements for the degree of Master of Science.

approximately 1 cm. through a 36-inch vacuum-jacketed column which was packed with glass helices. The reagent grade calcium oxide previously was rendered anhydrous by drying in a furnace for six hours at approximately 900°C. For each distillation the middle 50% of the product was retained. Values for several physical properties of each solvent were determined and are included with the data in Table 1.

Solutes. CHSA was obtained from Abbott Laboratories. Following drying to constant weight, it was used without further purification after titration with standard base reflected 99.7 ± 0.1% purity. Nitrobenzene (NB) was purified by subjecting it to several fractional freezings until a constant, maximum freezing point of 5.74°C was obtained. Its purity was further confirmed by determination of its dielectric constant, density and refractive index. The results were in excellent agreement with corresponding data in the literature (Timmermans, 1950).

Equipment and Procedures. The impedance bridge assembly, capacitance cells, temperature control, and principal aspects of the procedures for calibrating the cells and calculating the dielectric constants have been discussed previously in detail (Leader, 1951; Sears, Fortune and Blumenshine, 1966). All capacitance measurements were made at a frequency of 10 megacycles since some of the solutions were sufficiently conducting to prevent making measurements at 1 megacycle. The procedures for determining densities and refractive indices of liquids and solutions were routine. The method involving the use of toluene as an inert displacement solvent in determining the density of solid CHSA also has been described previously (Hovermale, Plucknett and Sears, 1957).

All measurements were made in duplicate at 25°C. Corresponding values were found to agree consistently within 0.3% for dielectric constants and within 0.02% for densities and refractive indices. Mean values of the experimental dielectric constant, density, and refractive index data are summarized in Table 1. The symbols which are used in Table 1 and throughout the remainder of the article are defined in the ensuing section on nomenclature.

Nomenclature

Symbols

ϵ = dielectric constant at 10 megacycles

ϵ_∞ = dielectric constant at infinite frequency; taken as being equal to $1.1\ n_2^2$

d = density in g. cm.$^{-3}$

Table 1. Summary of Experimental Data at 25°C.

$100\ X_2$	C	ϵ_{12}	d	n
		CHSA in DMA		
0.000	0.0000	38.7	0.9364	1.4361
2.963	0.3149	41.7	0.9551	1.4401
5.815	0.6113	44.4	0.9723	1.4441
8.207	0.8553	46.7	0.9865	1.4471
10.289	1.0633	48.5	0.9984	1.4500
12.754	1.3058	50.6	1.0123	1.4528
		CHSA in NM2PY		
0.000	0.0000	32.2	1.0280	1.4680
2.533	0.2604	34.3	1.0397	1.4702
5.799	0.5895	36.8	1.0546	1.4728
9.276	0.9317	39.7	1.0698	1.4753
12.068	1.1999	41.6	1.0813	1.4775
16.033	1.5729	44.7	1.0983	1.4801
		NB in DMA		
4.505	0.4821	38.4	0.9496	1.4419
9.105	0.9693	38.3	0.9627	1.4477
13.731	1.4553	38.1	0.9758	1.4535
18.185	1.9179	37.9	0.9879	1.4590
22.768	2.3913	37.7	1.0010	1.4646
		NB in NM2PY		
4.781	0.4945	32.4	1.0372	1.4726
8.863	0.9148	32.6	1.0447	1.4768
13.042	1.3430	32.7	1.0524	1.4805
18.113	1.8586	33.0	1.0613	1.4850
21.482	2.2003	33.1	1.0677	1.4880

n = refractive index (D line of sodium)
δ = limiting molar dielectric increment; constant in Equation 1
g = constant in Equation 1
a = constant in Equation 2
b = constant in Equation 3
Φ = apparent molal volume, cm.^{3} mole^{-1}
R = molar refraction, cm.^{3} mole^{-1}

C = moles of solute per liter of solution
X = mole fraction
M = gram formula weight
k = Boltzmann constant
N = Avogadro constant
T = temperature in °K.
μ_0 = dipole moment *in vacuo* or in gas phase expressed in Debye units
V = molar volume, $cm.^3\ mole^{-1}$

Subscripts

1 = designation of property of solvent
2 = designation of property of solute
12 = designation of property of solution

Results and Discussion

The data for each system were fitted by the method of least equares to Equations 1, 2 and 3:

$$(1)\quad \varepsilon_{12} = \varepsilon_1 + \delta C + g\,C^2$$

$$(2)\quad d_{12} = d_1 + a\,C$$

$$(3)\quad n_{12} = n_1 + b\,C$$

Other properties of the solute in each system were calculated as follows:

$$(4)\quad \Phi_2 = \frac{M_2 - 1000\ a}{d_1}$$

$$(5)\quad R_y = \frac{n_y^2 - 1}{n_y^2 + 2}\,V_y \qquad (y = 1 \text{ or } 12)$$

$$(6)\quad V_1 = \frac{M_1}{d_1}, \qquad V_{12} = \frac{M_1 + (M_2 - M_1)\,X_2}{d_{12}}$$

$$(7)\quad R_2 = R_1 + \frac{R_{12} - R_1}{X_2}$$

$$(8)\quad n_2^2 = \frac{\Phi_2 + 2\,R_2}{\Phi_2 - R_2}$$

Values of the constants determined for Equations 1 through 3 and of the properties of the solutes calculated using Equations 4 through 8 are summarized in Table 2.

The density of CHSA as a solid was determined experimentally to be 1.355 ± 0.002 g. cm.$^{-3}$ The density of NB as a liquid was found to be 1.1985 g. cm.$^{-3}$ From these data and the gram formula weights, the theoretical gram formula volumes were calculated to be 132.3 and 102.7 cm.^{3} mole^{-1} for CHSA and NB, respectively. The apparent molal volume for the solute in each system is listed in Table 2. The results reveal that some contraction or electrostriction occurs upon dissolution of CHSA in DMA and NM2PY but the amount of electrostriction is less than half of that observed for sulfamic acid in the same solvents (Sears, Fortune and Blumenshine, 1966). The value of Φ_2 for NB closely approaches the theoretical or ideal volume in each system indicating very little, if any, electrostrictive effect.

Table 2. Calculated Values for Constants in Equations 1 Through 3 and for Properties of Solutes

Constant or Property	CHSA in DMA	CHSA in NM2PY	NB in DMA	NB in NM2PY
δ	9.55	7.98	—0.39	0.43
g	—0.42	0	0	0
a x 10^4	583	447	270	180
b x 10^4	129	77	120	92
Φ_2	129.2	131.0	102.6	102.2
R_2	40.5	40.7	33.0	33.1
n_2	1.54	1.53	1.56	1.56

Several equations have been proposed in the literature for calculating the dipole moment of a solute from data from solutions of the solute in a polar solvent having a high dielectric constant. The equations used in this study, and for which the results are compared, are the Onsager and the Wyman equations.

The Onsager equation for a binary system may be written as follows (Onsager, 1936; Sears, Fortune and Blumenshine, 1966):

$$(9) \quad \epsilon_{12}V_{12} = \frac{2\pi N}{9kT}\left\{(\epsilon_{\infty_1}+2)^2\mu_{o_1}^2 + \left[(\epsilon_{\infty_2}+2)^2\mu_{o_2}^2 - (\epsilon_{\infty_1}+2)^2\mu_{o_1}^2\right] X_2\right\}$$

For a linear plot of $\epsilon_{12}V_{12}$ versus X_2 :

$$(10) \quad \mu_{o_2} = \frac{9kT\ (\text{slope} + \text{intercept})}{2\pi N \quad (\epsilon_{\infty_2}+2)^2}$$

The value of ϵ_∞ was appromimated in each case to be equal to 1.1 n_2^2 (Lin and Dannhauser, 1963).

The Wyman equation (Wyman, 1936; Greenstein and Winitz, 1961) may be expressed in the form of Equation 11 if the term, $(\epsilon_{\infty_2}+2)^2/2$, is substituted for the empirical constant, 8.5, in the denominator. This alteration has been discussed by Onsager who pointed out that the substitution leads to an approximate equivalence between the Wyman and the Onsager treatments of the relationship between the dielectric constant and dipole moment.

$$(11) \quad \mu_{o_2}^2 = \frac{9kT}{2\pi N}\left[\frac{1000\,\delta + \Phi_2(\epsilon_1+1)}{(\epsilon_{\infty_2}+2)^2}\right]$$

Values of the dipole moments of CHSA and NB which have been calculated using Equations 10 and 11 are summarized in Table 3. It may be observed that Equations 10 and 11 yield values for μ_{o2} which are in excellent agreement as predicted by Onsager.

Comparison data for the dielectric increments and dipole moments of CHSA and sulfamic acid are presented in Table 4. Although the dielectric increment of CHSA is only about 60% of that for sulfamic acid in the same solvent, the dipole moments show close agreement. It is well to keep in mind, however, that μ_{o2}^2 is related principally to $\epsilon_{12}V_{12}$ rather than simply to ϵ_{12}. The similarity of μ_{o2} values for CHSA and sulfamic acid in each solvent reflects that these species have comparable polar characteristics. The magnitude of the dipole moment and the very low conductance provide supporting evidence for a dipolar ionic structure.

The values of μ_{o2} which were obtained for nitrobenzene in this

Table 3. Calculated Values for the Dipole Moments of CHSA and NB

	μ_{o_2} of CHSA or NB	
System	Equation 10 (Onsager)	Equation 11 (Wyman)
CHSA in DMA	8.03	8.16
CHSA in NM2PY	7.49	7.52
NB in DMA	4.03	4.06
NB in NM2PY	4.06	4.16

Table 4. Comparison Data for Dielectric Increments and Dipole Moments of CHSA and Sulfamic Acid*

	δ		μ_{o_2}			
			Onsager Equation		Wyman Equation	
Solvent	SA	CHSA	SA	CHSA	SA	CHSA
DMA	15.8	9.7	7.94	8.03	7.95	8.16
NM2PY	13.1	8.0	7.66	7.44	7.65	7.52

* Sulfamic Acid abbreviated SA in table.

study are in good agreement with corresponding data for the gas phase and solutions in non-polar solvents (McClellan, 1963) as well as with some recent data obtained from solutions using an iso-dielectric polar solvent (Myers and Sun, 1966).

Summary

1. Dielectric constants, densities, and refractive indices of solutions of CHSA and NB in DMA and NM2PY have been determined at 25°C for solute concentrations ranging from 5 to 25 weight per cent. These data have been fitted by the method of least squares to appropriate equations.
2. The density of solid CHSA has been determined using toluene as an inert displacement solvent.

3. The apparent molal volumes of CHSA and NB in each non-aqueous solvent have been calculated. The observed values for CHSA are less than the gram formula volume for the solid indicating some contraction or electrostriction; however, the amounts of electrostriction are less than those for sulfamic acid in the same solvents. The apparent molal volume for NB in each solvent was found to be ideally equal to the gram formula volume of liquid NB.
4. The dielectric increment of CHSA was found to be about only 60% as large as that for sulfamic acid in each solvent.
5. The dipole moment of the solute in each system has been calculated using the Onsager and Wyman equations. The value calculated for CHSA is in excellent agreement with that for sulfamic acid in the same solvent providing evidence that CHSA has a dipolar structure like that of its parent. The dipole moment for NB in each solvent, calculated using the same procedures, compares very favorably with gas phase and solution values reported in the literature.

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ACTIVATION ENERGIES OF VISCOUS FLOW AND OTHER PHYSICO-CHEMICAL DATA FOR THE DIMETHYLSULFOXIDE—WATER SYSTEM

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The physical and thermodynamic properties of the dimethyl sulfoxide–water system have received much attention within the last decade. Further investigation which is described herein has yielded extensive information at several temperatures for 18 compositions ranging from pure dimethyl sulfoxide to pure water. The principal objectives of this paper are to present corroborative results, new data associated with different experimental conditions and, perhaps most importantly, the first values of activation energies of viscous flow for this binary system.

Experimental

Purification of Solvents and Preparation of Mixtures. Dimethyl sulfoxide (DMSO) was purified by subjecting it to several fractional freezings under an atmosphere of nitrogen. Modified six-liter separatory flasks were used for the fractional freezing flasks. The ambient temperature was controlled by use of a Precision Scientific Model 805 Incubator. During each freezing cycle the remaining 5 to 10% of unfrozen material was removed by suction provided by a vacuum pump. The final product froze transparently and had a freezing point of 18.52°C. Distilled water from a departmental supply was further purified by passing it through an Illco-Way research model ion-exchange column.

Sixteen mixtures, designed to cover the entire composition range in 5 to 10 mole % increments, were prepared in glass-stoppered flasks on a weight basis. Since the mixing of DMSO and water was sufficiently exothermic to raise the temperature of some of the mixtures 20° to 30°C, precautions were taken to allow the mixtures to cool to room temperature before final weights were taken. As for the determination of densities, calibrated weights were used and appropriate buoyancy corrections were applied. A sufficient quantity of each solution was prepared to enable duplicate or triplicate measurements to be made for each property.

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Equipment and Measuring Procedures. Densities of the DMSO–water mixtures were determined using 25-ml. Reischauer pycnometers. The volume of each pycnometer at each of several graduation marks was ascertained experimentally at 25°C using water as the calibrating medium. Corresponding volumes at the other temperatures were calculated taking into account the cubical coefficient of expansion of Pyrex glass.

Efflux times of the liquid mixtures were determined with sizes 25 and 50 Cannon-Fenske viscometers which were calibrated by the Cannon Instrument Company on the basis that water has an absolute viscosity of 1.0019 and 0.8902 centipoise at 20° and 25°C, respectively (Coe and Godfrey, 1944; Swindells, Coe and Godfrey, 1952). Recommendations concerning filling, alignment, and other procedural aspects in the use of the viscometers (Cannon and Fenske, 1938) were followed. Stopwatches for timing were calibrated against Station WWV time signals.

Refractive indices were measured with a Spencer Model 1470 Abbe refractometer. This instrument had sodium D-line compensating prisms equipped with jackets through which water from a thermostat could be circulated rapidly.

Dielectric constants were determined within 0.1 unit at a frequency of 10 megacycles. The Twin-T impedance bridge assembly, capacitance cells, and the principal aspects of the procedures for calibrating the cells, measuring capacitance changes, and calculating dielectric constants have been described in detail previously (Leader, 1951). The standard media which were used in the calibration of the capacitance cells were air and water which have dielectric constants of unity and 78.30 (Malmberg and Maryott, 1956), respectively, at 25°C. Measurements also at 1 megacycle indicated that the values of the dielectric constant of the DMSO–water mixtures were independent of frequency in the range of 1 to 10 megacycles.

Viscosities and densities were determined at 25°, 35°, 45° and 55°C whereas dielectric constants and refractive indices were measured at 25°C only. For all measurements the temperature was maintained within 0.02°C using a Sargent S-84805 water bath assembly. A Sargent S-71598 pump was used for rapidly circulating water through the jackets of the dielectric constant cells and refractometer.

All measurements were made in duplicate or triplicate. The precision and accuracy are believed to be comparable in the following cases: densities and refractive indices, ± 0.02%; dielectric constants, ± 0.2%. The precision of efflux time measurements was ± 0.2% or less; however, the error associated with some of the viscosity data may be slightly greater since surface tension corrections were not taken into consideration.

The fitting of data to various polynomial equations by the method of least squares and the calculation of values of the activation energy of viscous flow (E_{vis}) were accomplished using a digital computer.

Results and Discussion

Mean values of our experimental density, viscosity, dielectric constant and refractive index data are summarized in Tables 1, 2 and 3.

Several articles relative to the physical properties of the DMSO—water system have appeared previously in the literature (Lebel and Goring, 1962; Cowie and Toporowski, 1961; Lindberg and Kenttämaa, 1960). Excellent agreement exists between our results for the viscosities, densities and refractive indices at 25°C and those reported by Lebel and Goring. Good correlation also has been obtained with the viscosity and density data of Cowie and Toporowski at 25° and 45°C with the exception of their viscosity data for water and one or two of the most water-rich mixtures. A maximum difference of about 1% occurs; their data obviously are slightly high with respect to the currently accepted viscosity of 0.890 centipoise for water at 25°C. Taking into account that the 2.47 megacycle data of Lindberg and Kenttämaa are relative to the dielectric constant of water at 25°C being 78.54 (Wyman, 1930) rather than 78.30 (Malmberg and Maryott, 1956), our dielectric constant data corroborates excellently with theirs. All of our results for the DMSO—water system at 35° and 55° appear to be the first reported at these temperatures.

When viscosity is plotted *versus* composition, each isotherm exhibits a maximum at about 65 mole % water and the maximum becomes more pronounced as the temperature decreases. This is evidence of relatively strong attractive forces between DMSO and water molecules but should not be considered indicative of the formation of a compound such as $DMSO.2H_2O$. The freezing point curve shows an eutectic occurring at approximately 65 mole % water rather than evidence of a stable compound.

For each composition the plot of log η *versus* 1/T is slightly nonlinear, and hence the value for E_{vis} is dependent on temperature. This also reflects that the viscosity-temperature and E_{vis}-temperature relationships can be handled best by the following two equations (Girifalco, 1955; Misra and Varshni, 1961; Moore, Burkhardt and McEwan, 1956; Blumenshine and Sears, 1966):

$$(1) \qquad \log \eta = \alpha + \frac{\beta}{T} + \frac{\gamma}{T^2}$$

Equation 1 is known as the Girifalco equation. Differentiation of it with respect to 1/T makes possible the calculation of E_{vis} as a function of temperature. The symbols in these equations and in other places

$$(2) \qquad E_{vis} = 4.576 \frac{d(\log \eta)}{d(1/T)} = 4.576\left(\beta + \frac{2\gamma}{T}\right)$$

Table 1. **Experimental Density Data for DMSO—Water Mixtures**

Wt. % Water	Mole % Water	Densities (G. Ml.$^{-1}$) 25°	35°	45°	55°
0.00	0.00	1.0955	1.0855	1.0757	1.0657
1.84	7.51	1.0960	1.0861	1.0765	1.0664
4.56	17.18	1.0970	1.0873	1.0777	1.0677
8.04	27.47	1.0981	1.0882	1.0791	1.0693
11.58	36.23	1.0986	1.0892	1.0801	1.0703
15.53	44.36	1.0988	1.0895	1.0804	1.0708
17.79	48.73	1.0985	1.0895	1.0807	1.0708
22.27	55.71	1.0974	1.0885	1.0797	1.0703
26.69	61.20	1.0950	1.0862	1.0775	1.0689
31.54	66.65	1.0913	1.0827	1.0747	1.0655
34.46	69.49	1.0879	1.0798	1.0719	1.0630
37.74	72.44	1.0842	1.0759	1.0680	1.0594
44.61	77.72	1.0760	1.0691	1.0609	1.0525
51.85	82.36	1.0664	1.0594	1.0525	1.0447
64.85	88.89	1.0463	1.0403	1.0347	1.0279
78.03	93.90	1.0265	1.0217	1.0171	1.0113
89.78	97.44	1.0099	1.0062	1.0021	0.9973
100.00	100.00	0.9971	0.9941	0.9903	0.9857

Table 2. Experimental Viscosity Data for DMSO—Water Mixtures

Mole % Water	Viscosities (Centipoises)			
	25°	35°	45°	55°
0.00	1.996	1.654	1.396	1.195
7.51	2.087	1.725	1.449	1.237
17.18	2.266	1.848	1.540	1.303
27.47	2.516	2.032	1.676	1.406
36.23	2.786	2.217	1.806	1.500
44.36	3.103	2.436	1.951	1.599
48.73	3.286	2.560	2.038	1.655
55.71	3.567	2.732	2.142	1.724
61.20	3.718	2.808	2.182	1.737
66.65	3.753	2.820	2.175	1.725
69.49	3.691	2.766	2.133	1.684
72.44	3.540	2.648	2.040	1.617
77.72	3.219	2.415	1.867	1.483
82.36	2.743	2.081	1.623	1.300
88.89	2.001	1.549	1.231	1.003
93.90	1.461	1.150	0.930	0.768
97.44	1.125	0.897	0.735	0.616
100.00	0.890	0.717	0.594	0.505

throughout this article are defined subsequently in a section on nomenclature.

The results of fitting the viscosity data by the method of least squares to Equation 1 and calculating E_{vis} at 25°C with Equation 2 are summarized in Table 4. The difference between the observed and calculated values for viscosity in every case is less than 0.1%.

The standard deviations associated with the values for E_{vis} are incorporated also in Table 4. The maximum value for E_{vis} occurs at 72 mole % of water differing about 5 mole % with respect to the composition for which the viscosity maximum is observed for each isotherm.

Table 3. Experimental Dielectric Constant and Refraction Index Data and Calculated Molar Refraction and Molar Polarization Values for DMSO—Water Mixtures

Mole % Water	Dielectric Constant at 25°	Refractive Index at 25°	Molar Refraction (Ml. /Mole)	Molar Polarization (Ml. /Mole)
0.00	46.40	1.4768	20.15	66.90
7.51	48.75	1.4747	18.90	63.20
17.18	51.91	1.4718	17.30	58.37
27.47	55.59	1.4672	15.58	53.19
36.23	58.64	1.4635	14.14	48.76
44.36	61.73	1.4584	12.79	44.63
48.73	63.32	1.4551	12.15	42.85
55.71	65.96	1.4499	10.93	38.89
61.20	68.10	1.4432	10.14	36.60
66.65	70.05	1.4369	9.14	33.43
69.49	71.03	1.4319	8.74	32,38
72.44	72.29	1.4260	8.17	30.61
77.72	73.55	1.4163	7.38	28.45
82.36	74.78	1.4050	6.58	25.79
88.89	76.19	1,3840	5.52	22.70
93.90	77.09	1.3639	4.71	20.32
97.44	77.76	1.3468	4.15	18.64
100.00	78.30	1.3329	3.73	17.39

Table 4. Results for Viscosity Data in Table 2 Fitted to Equations 1 and 2

Mole % Water	$-\alpha$	$-\beta$	γ	E_{vis} at 25° (Cal. /Mole)	Std. Dev. in E_{vis} (Cal. /Mole)
0.00	0.99884	−14.163	111,254	3480	15
7.51	1.10290	−75.201	104,034	3537	14
17.18	0.85377	104.829	138,731	3778	27
27.47	0.95392	58.526	137,873	3964	11
36.23	0.74421	220.228	171,380	4253	8
44.36	1.09893	38.118	152,788	4515	40
48.73	1.43689	−154.195	127,697	4625	6
55.71	0.93705	201.540	192,505	4986	41
61.20	0.89110	270.973	210,711	5227	6
66.65	0.90932	283.321	216,385	5345	37
69.49	1.16430	138.670	195,267	5359	12
72.44	0.56745	522.697	255,104	5438	20
77.72	0.61283	506.516	250,641	5375	7
82.36	0.72399	436.525	233,479	5169	18
88.89	0.66758	470.213	226,331	4795	15
93.90	0.69288	465.050	214,889	4468	19
97.44	0.23092	762.107	252,304	4257	8
100.00	−0.41079	1172.665	308,627	4107	13

Plots of dielectric constant, density, or refractive index versus mole % composition are non-linear. Deviations from linearity are least for the dielectric constant plots.

Molar refraction and molar polarization data which are included in Table 3 have been calculated using the following equations:

$$(3)\qquad R_{12} = \frac{n_{12}^2 - 1}{n_{12}^2 + 2} \; \frac{78.13 - 60.11\,X_2}{d_{12}}$$

$$(4)\qquad P_{12} = \frac{\epsilon_{12} - 1}{\epsilon_{12} + 2} \; \frac{78.13 - 60.11\,X_2}{d_{12}}$$

Both R_{12} and P_{12} vary linearly with mole % or mole fraction composition. This suggests that these quantities can be mathematically related to composition by Equations 5 and 6. The results obtained

$$(5)\qquad R_{12} = R_1 + (R_2 - R_1)\,X_2$$

$$(6)\qquad P_{12} = P_1 + (P_2 - P_1)\,X_2$$

from fitting the molar refraction and molar polarization data in Table 3 by the method of least squares to Equations 5 and 6 are summarized in Table 5. The use of these equations does not imply that the DMSO–water mixtures are ideal, non-interacting mixtures. As a matter of fact, it is quite surprising that P_{12} varies linearly with X_2 since the DMSO–water system is characterized by extensive association in the liquid state. A similar pattern of behavior has been reported recently for two binary systems involving acetonitrile with hydrogen bonding liquids (Cunningham, Vidulich and Kay, 1967).

Table 5. Results for Fitting Molar Refraction and Molar Polarization Data to Equations 5 and 6

	Intercept (P_1)		Slope (P_2 - P_1)		$(P_{12})_{obs}$ - $(P_{12})_{calc}$	
Equation	Obs.	Calc.	Obs.	Calc.	Mean	Max.
5	20.15	20.10	16.42	16.35	0.03	0.05
6	66.90	66.78	49.51	49.57	0.18	0.32

Summary

1. Viscosities and densities have been determined at 25°, 35°, 45° and 55°C for 18 compositions in the dimethyl sulfoxide–water system.
2. Dielectric constants and refractive indices have been measured for the same compositions at 25°C.
3. Excellent corroboration usually exists for those cases in which the results of this study can be compared with those of other investigators.
4. The viscosity-temperature relationship for any composition in the dimethyl sulfoxide–water system can be excellently described by the Girifalco equation.
5. Activation energies of viscous flow have been calculated. E_{vis} for each composition exhibits a slight decrease with increasing temperature. At a given temperature such as 25°C, the values of E_{vis} exhibit a pronounced maximum for the composition corresponding to about 72 mole % water.
6. Both the molar refraction and the molar polarization vary linearly with mole fraction composition. It is surprising that this applies for the molar polarization since the dimethyl sulfoxide–water system is characterized by extensive association.

Nomenclature

Symbols

η	=	viscosity in centipoises
d	=	density in g. cm^{-3} or g. $ml.^{-1}$
ϵ	=	dielectric constant
n	=	refractive index (relative to sodium D-line)
E_{vis}	=	activation energy of viscous flow in cal. $mole^{-1}$
R	=	molar refraction in $cm.^3$ $mole^{-1}$
P	=	molar polarization in $cm.^3$ $mole^{-1}$
T	=	temperature in °K.
log	=	logarithm to base 10
X	=	mole fraction
α,β,γ	=	constants in Equations 1 and 2

Subscripts

1	=	designation of property of dimethyl sulfoxide
2	=	designation of property of water
12	=	designation of property of dimethyl sulfoxide–water mixture

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NEW MANNICH DERIVATIVES OF PHENOLIC COMPOUNDS AS POSSIBLE CARCINOSTATIC AGENTS

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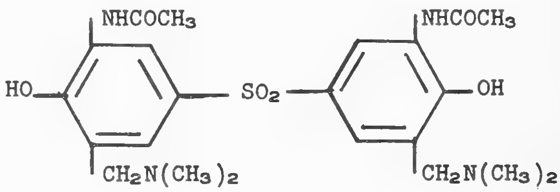
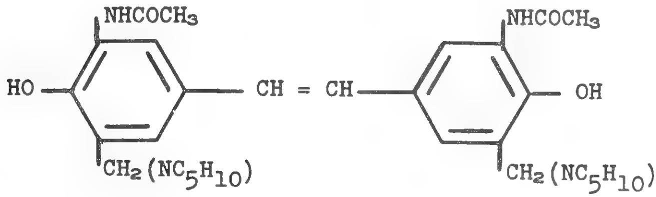
Previous work from our laboratory on the preparation and use of various amine derivatives of phenolic compounds has indicated that some of these compounds may have some carcinostatic activity in cancer investigations (1, 2, 3). In addition to the halogenated bisphenol types reported by Shaner and Meadow (2), some bisphenolic Mannich derivatives containing acetamido groups in the 2 and 2'-positions were described in a publication by Meadow and Reid (4), and later by O'Brien and Meadow (5). The dimethylaminomethyl derivative of 4,4'-sulfonylbis-(2-acetamidophenol) (I) is an example of such a derivative that has received some attention clinically as a carcinostatic agent. In addition to showing a noticeable carcinolytic effect in reticulum cell, sarcoma, lymphosarcoma, melanoma and carcinoma of the lung(1), these Mannich sulfone derivatives have the added advantage of being low in toxicity, having a high degree of solubility, and most of them can be made neutral at a pH of 7.



(I)

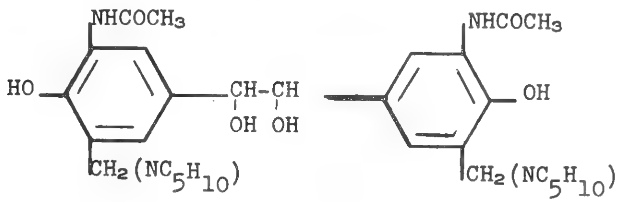
In 1961, Korpics, Smith and Meadow continued work on the preparation of acetamido derivatives as possible antimetabolites and reported six additional new Mannich derivatives which were similar in structure to (I) above (6). However, none of these compounds seemed to be quite as effective as the original dimethylaminomethyl compound (I) and its homologues in the treatment of malignant growths (1).

The present paper describes the preparation of some additional acetamido derivatives from 4,4'-dihydroxystilbene (II) and 4,4'-dihydroxyhydrobenzoin (III), as well as some other Mannich derivatives from miscellaneous phenols which have been included in our preparative and testing program. The latter group includes some



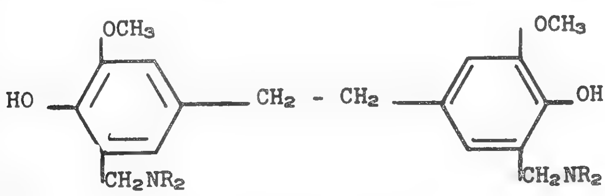
(II) where $-NC_5H_{10}$ = piperidino

dihydroxybibenzyl (IV) and dihydroxybenzil (V) compounds, and also a group of unique Mannich derivatives from piperazine (VI).

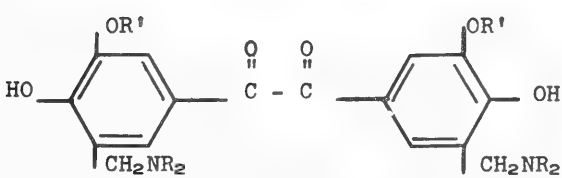


(III) where - NC_5H_{10} = piperidino

The piperazine Mannich compounds recorded in Table III, may be represented by the derivative (VI) obtained from two moles of p-chlorophenol and one mole of piperazine hydrate using two moles of formaldehyde as the condensing agent.

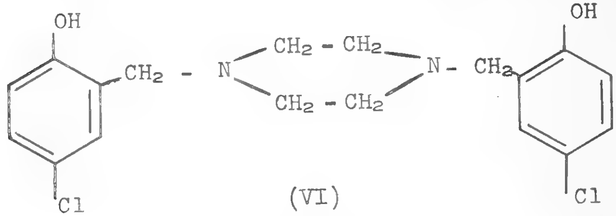


(IV) where - CH_2NR_2 = Mannich group



(V) where - CH_2NR_2 = Mannich gro

and R' = CH_3 or C_2H_5



(VI)

Experimental

Melting point determinations were made with a Fisher-Johns apparatus using a calibrated thermometer. Neutralization equivalents were obtained by the method of Seaman and Allen (7). The method of McKenzie and Wallace (8) was used to determine percentage of nitrogen in some of the compounds. Carbon, hydrogen and Dumas nitrogen determinations were furnished by Weiler and Strauss, Oxford, England.

Mannich compounds relative to dihydroxystilbene, dihydroxyhydrobenzoin, the dialkoxydihydroxybenzils, and dihydroxydimethoxybibenzil are placed in Table II, and those prepared from piperazine hydrate with miscellaneous phenols are found in Table III.

The Mannich derivatives of 3,3'-diacetamido-4,4'-dihydroxystilbene (II) and 3,3'-diacetamido-4,4'-dihydroxyhydrobenzoin (III) in Table II were somewhat difficult to obtain and several synthetic steps in their preparation were required. The same was true in obtaining the dihydroxy benzils (IV) and the dihydroxybibenzyl compound as intermediates for the other Mannich derivatives reported in Table II. The five intermediate bisphenols for these Mannich derivatives are listed in Table 1 and details for their preparation follows.

Bisphenol Intermediates for Mannich Derivatives in Table II

1. *3,3'-diacetamido-4,4'-dihydroxyhydrobenzoin.* This bisphenol was synthesized in three steps starting with 4,4'-dihydroxyhydrobenzoin. Preparation of the latter was described in an earlier publication (3).

(a) Preparation of 4,4'-dihydroxy-3,3'-dinitrohydrobenzoin. Twenty four and six tenths grams (0.10 mole) of 4,4'-dihydroxyhydrobenzoin (3) was slurried in 150 ml. of glacial $HC_2H_3O_2$ and stirred well at 20°C. while a solution of 12.7 ml. (0.203 mole) of HNO_3 in 150 ml. glacial $HC_2H_3O_3$ was slowly added (1 ml/min.). After addition was complete, the clear solution was stirred for 30 minutes and poured over 3 l. of cracked ice. The precipitate was filtered off and dried to give 17.06 g. (52.9%) of bright yellow powder, m.p. 185-190°. Recrystallization from dioxane-water gave 10.0 g of yellow solvated hexagonal plates melting at 190-195°. Further recrystallization from dioxane-water or xylene-acetic acid gave pure 4,4'-dihydroxy-3,3'-dinitrohydrobenzoin, m.p. 210-213° dec. (213-4° instantaneous m.p.).

Anal. Calc'd for $C_{14}H_{12}N_2O_8$: C, 50.01; H, 3.60; N, 8.33
Found : C, 49.82; H, 3.76; N, 8.05

(b) 3,3'-Diamino-4,4'-dihydroxyhydrobenzoin. A slurry of 2.0 g. of purified 4,4'-dihydroxy-3,3'-dinitrohydrobenzoin in 100 ml. of 50% aqueous ethanol was treated with 10 ml. of hydrazine whereupon the phenol dissolved to give a deep red solution. One-half gram of Raney nickel catalyst was added, and the mixture allowed to react on a steam bath until the red nitrophenolate color had disappeared (about 1 hour). The hot reaction mixture was filtered and washed with cold water to prevent drying of the precipitate. The latter was put in a mixture of 25 ml. of acetic acid and 100 ml. of cold dilute (1:10) HCl. Upon neutralization to pH 5.0 with conc. ammonium hydroxide, the solution deposited 1.36 g. (83%) of a pale tan powder, the 3,3'-diamino—4,4'-dihydroxyhydrobenzoin. The crude product contained 9.66% nitrogen (theoretical value = 10.14) but it was too insoluble to be crystallized and purified at this stage. The product decomposed to a black crystalline powder at about 250-255°.

(c) 3,3'-Diacetamido-4,4'-dihydroxyhydrobenzion. The crude diamino compound above (1.36 g., 0.005 mole) was treated with 1.0 ml. (0.0106 mole) of acetic anhydride in 50 ml. of glacial acetic acid and mixed well. The slurry was allowed to stand at room temperature over-night and was then filtered. The dried precipitate weighed 1.60 g. (89%) and melted at 234° dec. By extracting the product with boiling dioxane-water and again with boiling dioxane, a fairly pure product melting at 238-241° dec. (or 263-4° instantaneous m.p.) was obtained.

Anal. Calc'd for $C_{18}H_{20}N_2O_6$: N, 7.77.
Found : N, 7.59.

2. *3,3'-Diacetamido-4,4'-dihydroxystilbene.* The starting material for this bisphenol was 4,4'-dihydroxy-3,3'-dinitrohydrobenzoin (prepared in (a) above).

(a) Preparation of 4,4'-dihydroxy-3,3'-dinitrostilbene.

Five grams (0.015mole) of 4,4'-dihydroxy-3,3'-dinitrohydrobenzoin was powdered and heated rapidly to boiling with 20 ml. of 47% hydriodic acid containing 1.5% of hypophosphorous acid. Heating was contained for only 3 minutes with the appearance of a bright orange powder. The mixture was then diluted with water and filtered hot to give 3.88 g. of an orange solid. Impurities were extracted with boiling ethanol, leaving 3.18 g. (70.8%) of a residue of bright orange needles, melting at 274-280° dec. Further purification by recrystallization from xylene-acetic acid solvent gave a product melting at 282-4° dec.

Anal. Calc'd for $C_{14}H_{10}N_2O_6$: C, 55.63; H, 3.33; N, 9.27.
Found : C, 55.84; H, 316; N, 9.20.

(b) 3,3'-Diamino-4,4'-dihydroxystilbene. Three grams (0.01 mole) of 4,4'-dihydroxy-3,3'-dinitrostilbene (above) was dissolved in 50 ml. of 50% ethanol and reduced on a steam bath with 10 ml. of 95% hydrazine containing 0.5 g. of Raney nickel catalyst similar to the procedure described for 1 (b) above. The reaction product was washed through the filter into 50 ml. of acetic acid with 125 ml. of 1 *N* HC1. After neutralizing the acid solution to a pH of 5 with NH_4OH, 1.97 g. (84.9%) of a white precipitate formed which on heating gradually decomposed to a black crystalline solid between 230° and 300°. Like the diamino product in 1 (b), this amino compound was insoluble and in all neutral solvents tested could be "recrystallized" only by dissolving in boiling 50% aqueous acetic acid and reprecipitating with NH_4OH; this, however, resulted in no change in form or properties.

Anal. Calc'd for $C_{14}H_{14}N_2O_2$: N, 11.56
Found : N, 11.40.

(c) 3,3'-Diacetamido-4,4'-dihydroxystilbene. Acetylation of 0.93 g. (0.0038 mole) of 3,3'-diamino-4,4'-dihydroxystilbene with 15 ml. (0.015 mole) of acetic anhydride in glacial acetic acid for 48 hours at room temperature produced 1.19 g. (95%) of the diacetamido product, a light tan powder melting at 274-7°. Purification for analysis was accomplished by washing first with cold dilute NaOH, then with an excess of dilute HC1. This was repeated three times to give 0.66 g. of a white powder, m.p. 280-3° dec.

Anal. Calc'd for $C_{18}H_{18}N_2O_4$: N, 8.58.
Found : N, 8.62.

3. *Preparation of 4,4'-Dihydroxy-3,3'-dimethoxybenzil.* The method used here was essentially that of Pearl (9) in which 61.6 g. (0.20 mole) of 4,4'-dihydroxy-3,3'-dimethoxydrobenzion (3) was oxidized to the benzil compound using 78 g. (0.40 mole) of cupric hydroxide in 1 1. of glacial acetic acid. Recrystallization of 38 g. of the crude yellow

product from acetic acid gave a 58% yield of pale yellow needles, m.p. 234.5-235.5° (Pearl reported 233-4°).

4. *Preparation of 3,3'-Diethoxy-4,4'-dihydroxybenzil.* The starting material for this benzil compound was ethyl vanillin which was converted electrolytically to 3,3'-diethoxy-4,4'-dihydroxyhydrobenzoin (3). 11.13 g. (0.033 mole) of the latter was then converted into 6.33 g. of crude yellow 3,3'-diethoxy-4,4'-dihydroxybenzil by refluxing 1.5 hours with 13.0 g. (0.067 mole) of cupric hydroxide in 50 ml. of glacial acetic acid, as in Pearl's procedure (9) in compound No. 3 above. After two recrystallizations from hot glacial acetic acid, 5.15 g. (46.8%) of yellow prisms, m.p. 144.5-148.5°, was obtained. An analytical sample, melting sharply at 147-8.5°, was finally obtained by further recrystallization, first from 35% aqueous ethanol and then acetic acid.

Anal. Calc'd for $C_{18}H_{18}O_6$: OC_2H_5, 27.28
Found : OC_2H_5, 27.15.

5. *Preparation of 4,4'-Dihydroxy-3,3'-dimethoxybibenzyl.* Several attempts were made to prepare this compound by the method of Pearl (10) without success. Our method involved the hydrogenation of 3.3 g. (0.012 mole) of 4,4'-dihydroxy-3,3'-dimethoxystilbene (3) with a mixture of 0.1 g. of platinum dioxide and 100 ml. of absolute ethanol in a Burgess-Parr appartus for 16 hours under initial pressure of 3 atm. of hydrogen. The vessel was heated occasionally with an infra-red lamp to hold the stilbene in solution. After removal of the catalyst, the product crystallized from the mixture as clear white needles, m.p. 158-160°, weighing 2.66 g. (80%). Pearl's bibenzyl compound was reported to melt at 163-7°; however, Richtzenhain and von Hofe (11) reported its melting point at 158° which is in closer agreement with our product.

Preparation of Mannich Derivatives

Details for the preparation of the following four compounds are fairly representative for many of the twenty-five Mannich derivatives which are included in Tables II and III.

3,3'-Diacetamido-4,4'-dihydroxy-5,5'-bis(piperidinomethyl)-stilbene

One gram (0.0118 mole) of piperidine, 1.63 g. (0.005 mole) of 3,3'-diacetamido-4,4'-dihydroxystilbene (Table I), and 0.90 g. (0.011 mole) of 37% aqueous HCHO were slowly combined cold in the usual manner (4), using 25 ml of ethanol as solvent. The phenol was difficultly soluble and some remained undissolved even after refluxing for eight hours. The reaction was filtered hot, and the insoluble matter extracted with ethanol to give 0.58 g. of pale gray powder, m.p. 280-3° (unreacted starting material). The reaction mixture in the filtrate was chilled to give 1.10 g. (36.6% yield based on unrecovered starting material) of salmon pink needles, m.p. 155-7° i. (or 130-150° dec. when heated slowly on melting block); further recrystallization failed to change the instantaneous melting point. The analytical sample was recrystallized from methanol-methyl acetate and dried in a vacuum desiccator which produced pale tan prisms which became bright lavender on drying. Cause of the color change is not known. Analytical data for this compound are summarized in Table II (compound No. 2).

3,3'-Diethoxy-4,4'-dihydroxy-5,5'-bis (morpholinomethyl)-benzil

A mixture of 3.3 g (0.01 mole) of 3,3'-diethoxy-4,4'-dihydroxybenzil (See Table I) and 3.0 g. (0.035 mole) of morpholine in 50 ml. of ethanol was cooled and 2.0 g. (0.025 mole) of 37% HCHO was added slowly. After one hour at room temperature, the mixture was refluxed four hours and then filtered hot. The filtrate was concentrated to a volume of 25 ml. and chilled overnight to give 3.52 g. granular yellow solid, m.p. 171-6°. Recrystallization from benzene-ethanol gave 3.06 g. (51.8%) of solvated bright yellow waxy needles, m.p. 175-8°. Another recrystallization from pure ethanol, followed by prolonged drying at 60° under reduced pressure to liberate traces of solvent raised the melting point to 180-2° and reduced the neut. equivalent from 303.7 to 271.6. These and other data are recorded in Table II (compound No. 5). The piperidine Mannich derivative (compound No. 6) of this phenol was also solvated. Properties of the derivatives of 4,4'-dihydroxy-3,3'-dimethoxybenzil, which were similar to the above but much less stable, are also recorded in Table II.

4,4'-Dihydroxy-3,3'-dimethoxy-5,5'-bis-(morpholinomethyl)-bibenzyl.

One gram (0.0123 mole) of 37% aqueous HCHO was added in the usual manner (4) to a slurry of 1.37 g. (0.005 mole) of 4,4'-dihydroxy-3,3'-dimethoxybibenzyl and 1.25 g. (0.0145 mole) of morpholine in 25 ml. of methanol. After refluxing four hours, the mixture was treated with 20 ml. of benzene and concentrated to about 5 ml. on the steam bath; the solid mass of crystals was then washed with methanol, filtered, and dried to give 1.30 g. of crude product, m.p. 150-160°. One recrystallization from methanol produced 0.81 g. (34.3%) of white needles, m.p. 166-171°; a second recrystallization from methanol-benzene mixture gave a product melting at 175-8°.

Analytical data for this compound (No. 7) are listed in Table II. No other Mannich derivatives of this bisphenol were attempted because of difficulties encountered in its preparation (see description).

2,2'-Piperazinomethyl-bis-(4-chlorophenol). This Mannich derivative from piperazine (see formula VI), like others listed in Table III, was made by using a ratio of slightly more than two moles of phenol to one of piperazine. 6.4 g. (0.05 mole) of p-chlorophenol was dissolved in 15 ml. of absolute ethanol, chilled, and 4.1 g. (0.021 mole) of piperazine hydrate was added. To the cold mixture was added slowly 3.6 g. (.04 mole) of aqueous 37% formaldehyde, and contents of flask allowed to stand one hour at room temperature before refluxing. After refluxing 20 minutes small crystals began to appear; boiling was continued for two hours, then cooled, and white crystals were filtered off by suction. 6.1 g. of crude product, melting at 228-232°, represented a yield of 79%. Recrystallization from benzene gave a purer product, m.p. 242-4°, which readily sublimed at about 200°. The resulting compound, like many other Mannich derivatives from piperazine, was insoluble in dilute HCl. The analytical data for this and other piperazine Mannich compounds are listed in Table III. Only one of these (compound No. 15) contained one mole of piperazine to one mole of phenol; it was quite soluble in dilute acids.

Summary

Seven new Mannich compounds have been prepared from stilbestrol-like intermediates which contained either alkoxy or acetamido groups in the 3 and 3' positions. Three of the intermediates used have not been previously reported. In addition, eighteen new derivatives were made from piperazine via the Mannich reaction with numerous phonols for tests on physiological activity. However, one of the principal difficulties encountered with the piperazine derivatives, from a practical stand point, was their lack of solubility in dilute acids as well as organic solvents. Though some of the preparations reported here showed mild carcinostatic activity, none has appeared to be as effective as those in the series of Mannich derivaties of 4,4'-sulfonylbis-(2-acetamidophenol), (Formula I), which was first reported in 1954 by Meadow and Reid (4) and later by O'Brien and Meadow (5).

Acknowledgments

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Table I. Intermediate Bisphenols[a]

Bisphenol	M.p., °C	Yield, %[b]	Remarks
1. 3,3' Diacetamido-4,4'-dihydroxyhydrobenzoin	238-41 dec.[c]	89[d]	Prepared stepwise from 4,4'-dihydroxyhydrobenzoin.
2. 3,3'-Diacetamido-4,4'-dihydroxystilbene	280-3 dec.	95[e]	Four synthetic steps from 4,4'-dihydroxyhydrobenzoin.
3. 4,4'-Dihydroxy-3,3'-dimethoxybenzil[f]	234.5-5.5	58	From 4,4'-dihydroxy-3,3'-dimethoxybydrobenzoin by method of Pearl (9).
4. 3,3'-Diethoxy-4,4'-dihydroxybenzil	147-8.5	46.8	By oxidation of 3,3'-diethoxy-4,4'-dihydroxyhydrobenzoin with $Cu(OH)_2$.
5. 4,4'-Dihydroxy-3,3'-dimethoxy-bibenzyl	158-60	80	By hydrogination of 4,4'-dihydroxy-3,3'-dimethoxy-stilbene.

[a]Used as intermediates for preparing Mannich compounds reported in Table II. Compounds Nos. 1, 2 and 4 are new compounds; No. 5 was synthesized by a new method. [b]Crude product yield before recrystallization from appropriate solvent. [c]Melting poing when taken instantaneously (3) on the heating block was observed to be 263-4°C. [d]Percent yield from 3,3'-diamino-4,4'-dihydroxy-hyrobenzoin. Over-all yield from 4,4'dihydroxyhydrobenzoin was 39%. [e]Percent yield from 3,3'-diamino-4,4'-dihydroxystilbene. The over-all yield starting from 4,4'-dihydroxyhydrobenzoin was only 31%. [f]Previously prepared by Pearl (9) by oxidation of 4,4'-dihydroxy-3,3'-dimethoxy-hydrobenzoin with cupric hydroxide. He reported a melting point of 233-4°C.

Table II. Mannich Compounds From Synthetic Bisphenols[a]

	Mannich Groups in Ring Positions 5 5'	Melting Point °C	Yield,[b] %	Formula	Nitrogen, % Calc'd	Nitrogen, % Found	Neut. Equiv. Calc'd	Neut. Equiv. Found
	From 3,3'-Diacetamido-4,4'-dihydroxyhydrobenzoin[c]							
1.	Piperidinomethyl[d]	161-3	45.5	$C_{30}H_{42}N_4O_6$	10.0	9.66	277.3	287.0
	From 3,3'-Diacetamido-4,4'-dihydroxystilbene[e]							
2.	Piperidinomethyl	155-71[f]	39.6[g]	$C_{30}H_{40}N_4O_4$	10.76	10.55	260.3	266.7
	From 4,4'-Dihydroxy-3,3'-dimethoxybenzil[h]							
3.	Morpholinomethyl	126-9[i]	66.4	$C_{26}H_{32}N_2O_8$	5.60	5.32	250.3	259.8
4.	Piperidinomethyl	155-7	80.6	$C_{28}H_{36}N_2O_6$	5.64	5.45	248.3	254.6
	From 3,3'-Diethoxy-4,4'-dihydroxybenzil[j]							
5.	Morpholinomethyl	180-2	51.8	$C_{28}H_{36}N_2O_8$	5.30	5.12	264.3	271.6
6.	Piperidinomethyl	164-8[k]	61.2	$C_{30}H_{40}N_2O_6$	5.34	5.12	262.3	266.2
	From 4,4'-dihydroxy-3,3'-dimethoxybibenzil[l]							
7.	Morpholinomethyl	175-8	34.3[m]	$C_{26}H_{36}N_2O_6$	5.93	5.56	236.3	249.1

[a]Described in Table I. [b]Yield after one recrystallization from appropriate solvent, usually ethanol. [c]Listed in Table I (compound No. 1). [d]This compound appeared to contain a trace of solvent which could not be removed without decomposition of the compound. [e]Listed as compound No. 2 in Table I. [f]Instantaneous melting point; compound melted from 130° to 150° when heated slowly in the usual manner. [g]Yield after one recrystallization from methanol-ethylacetate mixture. [h]Compound No. 3. in Table I. [i]Actually a decomposition point. Recrystallization or drying resulted in loss of nitrogen, as well as lowering of the decomposition point. [j]Designated as compound No. 4 in Table I. [k]Sample slightly solvated; heating several hours at 80° under reduced pressure dried the sample but depressed the melting point to 159°-166°. [l]Compound No. 5 in Table I. [m]Yield after one recrystallization from methanol-benzene mixture.

Table III. Mannich Derivatives of Piperazine[a]

Compound Number	Phenol Linked to Mannich Group[b]	Melting Point, °C	Formula	Nitrogen % Calc'd	Nitrogen % Found	Solvent for Purification	Solubility in HCl
1.	p-Cresol (2)	227-7.5	$C_{20}H_{26}N_2O_2$	8.59	8.35	Benzene	No
2.	p-Chlorophenol (2)	242-4[c]	$C_{18}H_{20}N_2O_2Cl_2$	7.67	7.94	Benzene	No
3.	p-Ethylphenol (2)	196-8	$C_{22}H_{30}N_2O_2$	7.89	7.98	Ethanol	No
4.	p-Methoxyphenol (2)	203-4	$C_{20}H_{26}N_2O_4$	7.82	7.53	Ethanol or benzene	Yes
5.	p-Bromophenol (2)	252-2	$C_{18}H_{20}N_2O_2Br_2$	6.14	6.10	Benzene	No
6.	p-ter-Butylphenol (2)	257.5-8	$C_{26}H_{38}N_2O_2$	6.83	6.42	Benzene	No
7.	p-Anilinophenol (2)	245-7.5[e]	$C_{30}H_{32}N_4O_2$	11.67	11.78	Xylene[f]	No
8.	p-ter-Amylphenol(2)	204-5	$C_{28}H_{42}N_2O_2$	6.39	6.17	Ligroin	No
9.	p-Cyclohexylphenol (2)	246-8	$C_{30}H_{42}N_2O_2$	6.06	5.85	Benzene	No
10.	p-Phenylphenol (2)	234-5	$C_{30}H_{30}N_2O_2$	6.22	6.05	Benzene	No
11.	p-Hydroxyacet-anilide(2)	261-3	$C_{22}H_{28}N_4O_4$	13.59	13.50	Isopropanol	Yes
12.	N-Acetyl-p-anilino-phenol (2)	250-3	$C_{34}H_{36}N_4O_2$	9.93	9.75	Benzene-ligroin	Yes
13.	Guaiacol (4 or 6)[g]	185-7	$C_{20}H_{26}N_2O_4$	7.82	7.70	Benzene	Yes
14.	6-Chlorothymol (2)	266-7	$C_{26}H_{36}N_2O_2Cl_2$	5.84	5.96	Ethanol	No

Table III. (continued)

15.	6-Chlorothymol (2) (mono)[h]	173-5[i]	$C_{15}H_{23}N_2OCl$	9.91	9.85	Ethanol	Yes
16.	4-Chloro-3,5-dimethyl-phenol (2)	271-3	$C_{22}H_{28}N_2O_2Cl_2$	6.62	6.38	Benzene	No
17.	2,4,5-Trichloro-phenol (5)	248-9	$C_{18}H_{16}N_2O_2Cl_6$	5.57	5.40	Benzene	No
18.	N,N-Diethylvanilla-mide (6)	220-2	$C_{30}H_{44}N_4O_4$	10.06	9.66	Ethanol	Yes

[a]Typical formula of these derivatives is shown in VI with piperazino Mannich group linked to each of two moles of p-Chlorophenol at the 2-position in the phenol ring. [b]Number in parenthesis indicates position in the phenol ring where Mannich group is attached. [c]Some sublimation begins at about 200° [d]Solvates easily with ethanol, requiring over-night drying in vacuum dessicator. [e]Instantaneous melting point: 247-8°. [f]Orange-red crystals from hot xylene. [g]Probably composed of a mixture of isomers having Mannich attachments at either the 4 or 6 position in quaiacol. [h]Mono-Mannich derivative consisting of one mole each of chlorothymol and piperazine, produced by using a large excess (300%) of piperazone. [i]Lavender colored crystals, very soluble in dil. HCl.

SYNTHESIS OF SOME AMINE SUBSTITUTED BISPHENOLS RELATED TO THE STILBENEDIOLS

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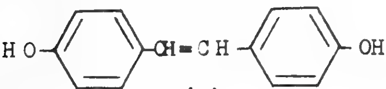
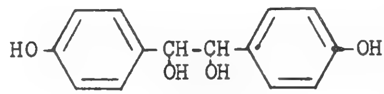
Our investigation of the use of amine substituted phenols as possible carcinostatic agents has led to the preparation of some new Mannich derivatives of certain bisphenols which are related structurally to 4,4'-dihydroxystilbene (I) and its glycol analogue, 4,4'-dihydroxyhydrobenzoin (II).

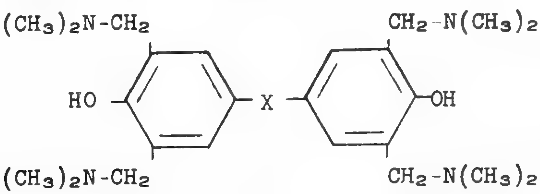


(I)

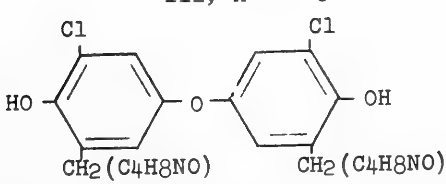


(II)

Geschickter, Copeland and Scholler (1) reported that certain phenols, when converted to amine derivatives by means of the Mannich reaction, were able to inhibit the growth of the Rous chicken sarcoma. Two of these compounds, 4,4'-dihydroxy-3,3', 5,5'-tetrakis (dimethylaminomethyl)-diphenylketone (III) and 4,4'-dihydroxy-3,3',5,5'-tetrikis (Dimethylaminomethyl)-diphenylether (IV) were noticeably active in this connection. Meadow and Reid (2) and other workers in this laboratory (3) have prepared similar compounds for further study. Among those which showed some antimetabolite activity were amine derivatives of 3,3'-dichloro-4,4'-dihydroxy-diphenylether, such as the morpholinomethyl derivatives in V, and others.



III, $X = -\overset{\text{O}}{\text{C}}-$



(V)

The basic similarity of the carbon skeletons of these bisphenols to that of diethylstilbestrol (DES), a widely used carcinostatic compound, is worthy of note. No studies have been reported on tumor therapy with stilbenediols other than DES itself, but 4-aminostilbenes have been extensively studied. (4, 5, 6) With this in mind, a large number of amino derivatives of some stilbenediols (I) and similar hydrobenzoins (II) have been synthesized in order to observe their physiological properties. To date, a few of the amine substituted compounds of the latter type have shown mild estrogenic activity (7) and further study along this line is indicated. The amine derivatives studied were prepared from nine bisphenol intermediates none of which were commercially available, with the excption of diethylstilbestrol (8). Accordingly, it was necessary either to devise new methods or revise existing ones for satisfactory preparation of these compounds in sufficient quantity and purity for conversion to Mannich derivatives in later stages. Eight of these bisphenols are listed in Table I which includes some information about synthesis methods employed. Three of these compounds have not been previously reported.

The Mannich derivatives listed in Tables II and III were prepared by the method of Meadow and Reid (2) with slight modifications principally in the methods used to isolate and purify the free base products. A representative preparation is described in detail.

Experimental

Melting point determinations were made with a Fisher-Johns apparatus using a calibrated thermometer. Some of the compounds decomposed slowly before melting and the observed melting temperature would often depend on the rate of heating. This behavior was characteristic of many of the hydrobenzoins studied. For such compounds the instantaneous melting point (a tedious procedure denoted by "i" in the tables) is defined as the temperature at which a small crystal melts instantly (5 to 10 seconds) when dropped on a clean cover slip on the heating block. Neutralization equivalents were obtained by the method of Seaman and Allen (9). Chlorine analyses were made by the conventional Parr bomb method. For nitrogen determinations, the method of McKenzie and Wallace (10) was modified to permit use of larger samples by increasing amount of reagents. Carbon, hydrogen, and alkoxyl determinations were furnished by Weiler and Strauss, Oxford, England. The results are summarized in Tables I to III. With slight modification, the hydrobenzoins were prepared in an electrolysis cell, similar to that described by Pearl (11) using lead electrodes which were previously etched with dilute HNO_3 before each use.

3,3'-Dichloro-4,4'-dihydroxyhydrobenzoin. Starting with p-hydroxybenzaldehyde, a 65% yield of 3-chloro-4-hydroxybenzaldehyde, colorless needles, m.p. 136-7° (Lit. 139°), was obtained by treatment with sulfuryl chloride in acetic acid at room temperature. Twenty grams (0.128 mole) of 3-chloro-4-hydroxybenzaldehyde was dissolved in 200 ml. of 2 *N* NaOH in a 400 ml. beaker, fitted with lead electrodes, porous cup and the anolyte. A current of 2 amperes was passed through the cell for five hours, using a 6 volt Tungar battery charger as a source of current. The catholyte was then filtered and neutralized with a slow stream of sulfur dioxide. The precipitate was removed by filtration, washed with water and dried to give 18.4 g. (91.5%) of fine, cleary crystals, m.p. 246-8° i. Recrystallization from ethanol produced bright prisms, m.p. 254-6° i.

Anal. calcd. for $C_{14}H_{12}Cl_2O_4$: C-, 22.50. Found, 22.39.

3,3'-Dichloro-4,4'-dihydroxystilbene. A mixture of 75 ml. of 47% hydriodic acid and 5 ml. of 50% hypophosphorous acid was added to 15.8 g. (0.05 mole) of 3,3'-dichloro-4,4'-dihydroxyhyrobenzoin in a 300 ml. Erlenmeyer flask and immediately placed on a preheated electric hot plate. The mixture was swirled vigorously and brought to a boil in about two minutes, at which time the initially brown slurry had become white again. At this point 100 ml. of boiling distilled water was added and filtered hot. The light tan solid was washed rapidly with boiling water and dried to give 12.8 g. (91%) of crude product, m.p. 180-90°. Recrystallization from 50% aqueous ethanol gave 9.95 g. of pale tan needles, m.p. 194-6°.

Anal. Calcd. for $C_{14}H_{10}Cl_2O_2$: C, 59.81; H, 3.59; Cl, 25.22.
Found : C, 59.72; H, 3.70; Cl, 25.52.

4,4'-Dihydroxy-3,3'-dimethoxystilbene. Attempts to prepare this stilbene from desoxyvanilloin using Pearl's method (12) were unsuccessful. A procedure was devised, however, in which a fair yield of the stilbene was obtained after reducing 4,4'-dihydroxy-3,3'-dimethoxyhydrobenzoin with zinc dust and mercuric chloride in ethanol. The hydrobenzoin was prepared from vanillin by an adaptation of Pearl's procedure (11). One hundred grams of vanillin was electrolyzed for 5 hours at 6 amperes with lead electrodes (3 lb./1 sq. ft. and 8 sq. decimeters in area) in a large cell of 3 liters capacity. The product was precipitated with SO_2, washed with water and dried to give

71.3 g. (70.9%) of bright prisms, m.p. 234-6° i (222-4° dec. by ordinary melting block procedure). After recrystallization from dioxane-water, the product melted at 241-3° i (235-8° dec.). Ten grams (0.033 mole) of this 4,4'-dihydroxy-3,3'-dimethoxyhydrobenzoin was then added to a boiling suspension of 20 g. of zinc dust and 2.0 g. of mercuric chloride in 100 ml. of 95% ethanol. Six ml. of conc. HC1 was added, followed by alternate additions of 5 g. zinc dust and 3 ml. of HC1 (two additions of each at one minute intervals). Boiling was allowed to continue 5 minutes after the last addition and filtered. Zinc was extracted once with hot ethanol which was combined with the filtrate and chilled to give 3.9 g. (43.6%) of white needles, m.p. 185-208°. Two recrystallizations from ethanol produced 2.29 g. of product melting at 216-7°, which did not depress the m.p. of authentic *trans*-4,4'-dihydroxy-3,3'-dimethoxystilbene (13). Conversion to the diacetate was accomplished with boiling acetic acid in pyridine and recrystallizing some from ethanol-acetic acid mixture to produce fine white needles, m.p. 227-8° (Lit. 226-7°) (12).

3,3'-Diethoxy-4,4'-dihydroxystilbene. One hundred grams (0.602 mole) of ethyl vanillin was dissolved in 1.5 l. of 2 *N* NaOH and electrolyzed for 10 hours at 6 amperes in a large electrolytic cell with lead electrodes. The product was precipitated with sulfur dioxide, filtered, washed well with water and dried to give 94.8 g. (94.2%) of 3,3'-diethoxy-4,4'-dihydroxyhydrobenzoin, a white powder, m.p. 224-5° i (205-10° dec). Recrystallization from dioxane-water gave clear prisms, m.p. 225-7° (also 225-7° i). The 3,3'-diethoxy-4,4'-dihydroxystilbene was subsequently prepared from the hydrobenzoin as follows. Ten grams of zinc dust (best grade), 1.0 g. of mercuric chloride, and 100 ml. of 95% ethanol were combined in a 500 ml. Erlenmeyer flask and heated to boining. Ten grams (0.03 mole) of 3,3'-diethoxy-4,4'-dihydroxyhydrobenzoin was added, and additions of 3 ml. cc conc. HC1 were alnternated with additions of 5 g. of zinc dust at one minute intervals for 3 additions of each; the mixture was allowed to boil 15 minutes more and filtered. The zinc was washed with hot ethanol, and the filtrate and washings were combined and chilled to give 4.48 g. of light pink powder, m.p. 145-163°. Recrystallization from ethanol gave 3.81 g. (41.9% of fiberlike needles, m.p. 163-8°. This product from xylene produced dark red solvated needles which lost solvent at about 100° and then melted sharply at 166-8°. Sublimation produced a product melting at 166.5-8.5°.

Anal. Calcd. for $C_{18}H_{20}O_4$: C, 71.98; H, 6.71; OC_2H_5, 30.01.

Found : C, 71.85; H, 6.62; OC_2H_5, 31.78.

4,4'-Dihydroxy-3,3'-dimethoxy-5,5'-bis(pyrrolidinomethyl)-hydrobenzoin.

The procedure for preparing these Mannich compounds was essentially that of Meadow and Reid (2). A slurry of 12.24 g. (0.04 mole) of 4,4'-dihydroxy-3,3'-dimethoxyhydrobenzoin and 10.0 g. (0.106 mole of pyrrolidine in 200 ml. of methanol was cooled in an ice bath and ten grams (0.123 mole) of 37% aqueous HCHO was added dropwise over a ten minute period, while the flask was swirled vigorously and held near 0-5°C. After addition was complete the mixture was allowed to stand one hour at room temperature and then refluxed gently for four hours. The reaction mixture was filtered hot, evaporated to about 75 ml. and cooled. The dense mass of crystals was filtered off and washed with small portions of cold methanol to remove a green color. Recrystallization of crude product (14.3 g.) from 75% ethyl acetate-25% methanol gave 8.9 g. (47%) of fine white needles, m.p. 175-8°. The product decomposed slowly on standing and rapidly on drying at 60°, a property that it shared with all pyrrolidine Mannich derivatives prepared in this study. The analytical sample was freshly recrystallized from ethyl acetate-methanol and dried in a vacuum desiccator at room temperature for 48 hours before analysis.

The melting points, yields and analytical data of all Mannich derivatives are reported in Tables II and III.

Summary

The study of new amine substituted derivatives of diethylstilbestrol and related bisphenols of the stilbene and hydrobenzoin series as possible carcinostatic agents has led to the synthesis of some thirty-two such compounds, some of which are reported to have interesting estrogenic action. Three new intermediate bisphenols are described, as well as new procedures for several other bisphenols used.

Acknowledgments

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Table I. Intermediate Bisphenols

		M.p., °C[a]	Yield, %[b]	Remarks
1.	4,4'-Dihydroxyhydrobenzoin[c]	240-2 i[d]	76.7	Obtained by electrolytic reduction of p-hydroxybenzaldehyde.[e]
2.	4,4'-Dihydroxy-3,3'-dimethoxyhydrobenzoin[f]	241-3 i	70.9	Prepared by method adapted after Pearl (11).
3.	3,3'-Diethoxy-4,4'-dihydroxyhydrobenzoin[g]	225-7 i	94.2	Prepared from ethylvanillin[h] by modification of Pearl's procedure.
4.	3,3'-Dichloro-4,4'-dihydroxyhydrobenzoin[i]	254-6 i	91.5	Electrolytic reduction of 3-chloro-4-hydroxybenzaldehyde.
5.	4,4'-Dihydroxystilbene[j]	287-91	88.5	Obtained by reduction of compound No. 1 with HI.[k]
6.	4,4'-Dihydroxy-3,3'-dimethoxystilbene[l]	216-7	25.8	Prepared by reduction of compound No. 2 with Zn dust, $HgCl_2$ in ethanol.
7.	3,3'-Diethoxy-4,4'-dihydroxystilbene[i]	166.5-8.5	41.9	By reduction of compound No. 3 with Zn dust, $HgCl_2$ in ethanol.
8.	3,3'-Dichloro-4,4'-dihydroxystilbene[i]	194-6	91	Obtained by reduction of compound No. 4 with HI and H_3PO_2.

a. Instantaneous melting points denoted by "i".
b. Crude product yield, before recrystallization in appropriate solvents.
c. Previously prepared by Allen[14] who reported m.p. of 215.5°; earlier workers[15,16] reported 222°
d. Non-instantaneous m.p. as observed: 210-220°.
e. See details in experimental part for preparing 3,3'-dichloro-4,4'-dihydroxyhydrobenzoin.
f. Previously reported by Pearl[11] who recorded a m.p. of 233-4°.
g. Previously prepared by Pearl[11] who reported a m.p. of 219-220°.
h. Kindly furnished by the Monsanto Chemical Co., St. Louis, Mo.
i. New compound.
j. Wood's method[17] of heating trithio-p-hydroxybenzaldehyde with copper powder to produce this stilbene was unsatisfactory.
k. Details of synthesis similar to procedure described for 3,3'-dichloro-4,4'-dihydroxystilbene.
l. Prepared from desoxyvanilloin by Pearl[11] who reported a m.p. of 211-2°.

Table II. Data for Mannich Derivatives of Bisphenols

No.	Mannich groups and their ring positions	Melting Point, °C.	Yield[a] %	Formula	Nitrogen, % Calcd.	Nitrogen, % Found	Neut. Equivalent Calcd.	Neut. Equivalent Found
			From Diethylstilbestrol[b]					
1.	Dimethylaminomethyl (3,3')	143-5	29.4	$C_{24}H_{34}N_2O_2$	7.32	7.22	191.3	192.0
2.	Morpholinomethyl (3,3')	218-9 i[c] (211-6)	49.8	$C_{28}H_{38}N_2O_4$	6.00	5.80	233.3	237.1
3.	Piperidinomethyl (3,3')	166-8	50.2	$C_{30}H_{42}N_2O_2$	6.05	5.96	231.3	232.8
			From 4,4'-Dihydroxyhydrobenzoin					
4.	Morpholinomethyl (5,5')	223-4 i[c] (212-7)	8.0	$C_{24}H_{32}N_2O_6$	6.30	6.22	222.3	226.4
5.	Piperidinomethyl (5,5')	202-3 i[c] (198-203)	7.0	$C_{26}H_{36}N_2O_4$	6.35	6.10	220.3	223.6
			From 4,4'-Dihydroxy-3,3'-dimethoxyhydrobenzoin					
6.	Morpholinomethyl (5,5')	199-200	51.5	$C_{26}H_{36}N_2O_8$	5.55	5.45	252.3	256.8
7.	Piperidinomethyl (5,5')	180-1	46.5[d]	$C_{28}H_{40}N_2O_6$	5.60	5.48	250.3	252.1
8.	Pyrrolidinomethyl (5,5')	175-8	47.0[e]	$C_{26}H_{36}N_2O_6$	5.93	5.77	236.3	240.7
9.	N-Methylpiperazinomethyl (5,5')[f]	193-5	58.0	$C_{28}H_{42}N_4O_6$	10.56	10.18	132.7	136.4

Table II. Data for Mannich Derivatives of Bisphenols (Continued)

No.	Mannich groups and their ring positions	Melting Point, °C.	Yield,[a] %	Formula	Nitrogen, % Calcd.	Nitrogen, % Found	Neut. Equivalent Calcd.	Neut. Equivalent Found
			From 3,3'-Dichloro-4,4'-dihydroxyhydrobenzoin					
10.	Morpholinomethyl (5,5')	224-6	19.4	$C_{24}H_{30}Cl_2N_2O_6$	5.46	5.33	256.7	258.5
11.	Piperidinomethyl (5,5')	260-5 i[c] (233-8)	40.2	$C_{26}H_{34}Cl_2N_2O_4$	5.50	5.22	254.7	258.4
			From 3,3'-Diethoxy-4,4'-dihydroxyhydrobenzoin					
12.	Morpholinomethyl (5,5')	178-180	50.7	$C_{28}H_{40}N_2O_8$	5.26	5.12	266.3	273.1
13.	Piperidinomethyl (5,5')	166-8	33.1	$C_{30}H_{44}N_2O_6$	5.30	5.17	264.3	269.1
14.	Pyrrolidinomethyl (5,5')	65-7	30.5[h]	$C_{28}H_{40}N_2O_6$	5.59	5.24	250.3	266.0
15.	N-Methylpiperazinomethyl (5,5')	102-5	38.8	$C_{30}H_{46}N_4O_6$	10.03	9.93	139.7	143.4

[a]Yield of product after one recrystallization from ethanol unless otherwise indicated. [b]This trans isomer was kindly furnished by K. and K. Laboratories, Long Island City, N. Y. [c]Instantaneous melting point; the parenthesized value is that from slow heating (2° to 3° per minute). [d]Recrystallized from methanol. [e]Recrystallized from methanol-ethyl acetate mixture. [f]This compound could not be obtained entirely free from the monosubstituted product. [g]Compound quite unstable; slight decomposition noted at room temperature in vacuum desiccator. [h]Recrystallized once from methanol, then from methanol-ethyl acetate.

Table III. Data for Mannich Derivatives of Bisphenols

No.	Mannich Groups and their ring positions	Melting Point, °C.	Yield,[a] %	Formula	Nitrogen, % Calcd.	Nitrogen, % Found	Neut. Equivalent Calcd.	Neut. Equivalent Found
			From 4,4'-Dihydroxystilbene					
16.	Dimethylaminomethyl (3,3')	189-192	43.6	$C_{20}H_{26}N_2O_2$	8.58	8.40	163.2	166.7
17.	Diethylaminomethyl (3,3')	106-7	28.0	$C_{24}H_{34}N_2O_2$	7.32	7.19	191.3	195.4
18.	Morpholinomethyl (3,3')	214-5 i[b] (211-215)	48.7	$C_{24}H_{30}N_2O_4$	6.82	6.62	205.3	208.3
19.	Piperidinomethyl (3,3')	189-190[c]	68.6	$C_{26}H_{34}N_2O_2$	6.89	6.74	203.3	204.9
20.	Tetra-(piperidinomethyl) (3,3',5,5')[d]	186-7[c]	29.2	$C_{38}H_{56}N_4O_2$	9.32	9.08	150.2	156.6
21.	Pyrrolidinomethyl (3,3')	154-5	60.6	$C_{24}H_{30}N_2O_2$	7.40	7.33	189.3	190.8
22.	N-Methylpiperazinomethyl (3,3')	160-3	12.4	$C_{26}H_{36}N_4O_2$	12.83	12.31	109.2	115.4
		From 4,4'-Dihydroxy-3,3'-dimethoxystilbene						
23.	Dimethylaminomethyl (5,5')	165-8	35.2	$C_{22}H_{30}N_2O_4$	7.25	6.96	193.2	199.4
24.	Morpholinomethyl (5,5')	222-3 i[b] (214-222)	72.1	$C_{26}H_{34}N_2O_6$	5.95	5.76	235.3	242.0
25.	Piperidinomethyl (5,5')	217-8 i[b] (212-215)	85.3	$C_{28}H_{38}N_2O_4$	6.00	5.83	233.3	242.0

Table III. Data for Derivatives of Bisphenols (Continued)

No.	Mannich Groups and their ring positions	Melting Point, °C.	Yield,[a] %	Formula	Nitrogen, % Calcd.	Nitrogen, % Found	Neut. Equivalent Calcd.	Neut. Equivalent Found
			From 3,3'-Diethoxy-4,4'-dihydroxystilbene					
26.	Dimethylaminomethyl (5,5')	194-5 i[b] (185-191)	55.3[e]	$C_{24}H_{34}N_2O_4$	6.76	6.54	207.3	214.0
27.	Diethylaminomethyl (5,5')	141-4	57.5[e]	$C_{28}H_{42}N_2O_4$	5.95	5.81	235.3	237.9
28.	Morpholinomethyl (5,5')	186-8[f]	56.5	$C_{28}H_{38}N_2O_6$	5.62	5.59	249.3	252.5
29.	Piperidinomethyl (5,5')	185-7[f]	83.8	$C_{30}H_{42}N_2O_4$	5.66	5.56	247.3	252.2
			From 3,3'-Dichloro-4,4'-dihydroxystilbene					
30.	Dimethylaminomethyl (5,5')	163-6	25.8	$C_{20}H_{24}Cl_2N_2O_2$	7.09	6.90	197.7	200.6
31.	Morpholinomethyl (5,5')	217-8 i[b] (212-215)	43.6[g]	$C_{24}H_{28}Cl_2N_2O_4$	5.84	5.69	239.7	246.2
32.	Piperidinomethyl (5,5')	244-6 i[b] (230-250)	40.2[g]	$C_{26}H_{32}Cl_2N_2O_2$	5.89	5.68	237.7	238.7

[a]Yield of once recrystallized product, usually from ethanol unless otherwise indicated. [b]Instantaneous melting point; the parenthesized value is that from slow heating by ordinary procedure. [c]The mixed melting point of compounds No. 19 and No. 20 was 176-190°. [d]Product contaminated with slight amount of trisubstituted compound. It appeared that repeated recrystallizations resulted in enrichment of the trisubstituted derivative at the expence of the tetrasubstituted product, as indicated from analytical data. [e]Recrystallized from methanol. [f]The mixed melting point of compounds 28 and 29 was 170-185°. [g]Recrystallized from benzene-ethanol mixture.

HALOGENATED AMINO BISPHENOLS AS POSSIBLE CARCINOSTATIC AGENTS

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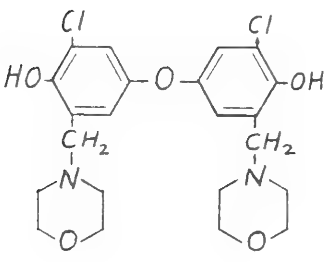
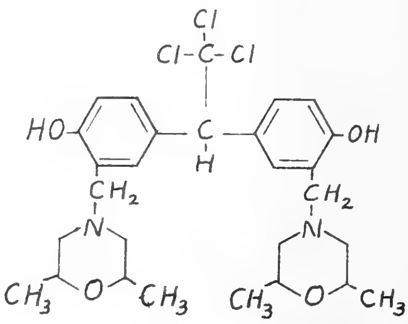
For several years numerous projects* have been carried out here on the preparation of new types of amino phenols and bisphenols with the view that such compounds might possess some important physiological activity. One of the principal aims of this program has been the hope of finding one or more compounds which might show some carcinolytic activity, however, slight, in retarding the growth of cancerous tissues and tumors in animals. Geschickter, Copeland and Scholler (1) reported that certain phenols, when converted to amine derivatives by use of the Mannich reaction (2), were able to inhibit the growth of the Rous chicken sarcoma. Meadow and Reid (3) and a number of their associates have prepared a large number of similar compounds for further study. Many of the amino bisphenols thus prepared have contained halogen atoms, either attached directly to the ring or in a side chain, as indicated in (I) and (II) below.



(I)



(II)

Among those compounds tested to date, 3,3'-dichloro-4,4'-dihydroxy-5,5'-bis(morpholinomethyl)-diphenylether (I above) and 4,4'-dihydroxy-3,3'-bis (2,6-dimethyl-morpholinomethyl)-diphenyl-2,2,2-trichlor-

* This work has been supported in part by contributions from the Geschickter Fund for Medical Research in Washington, D.C. and all physiological tests and evaluations have been conducted by the Fund.

oethane (II above), are examples of two halogen-containing amino bisphenols which have shown some encouragement in this connection (4). The synthesis of the first compound (I) mentioned above has been reported in an earlier publication (3). Since then, many other bisphenols containing both chlorine and Mannich (amino) groups, exemplified by compound II above, have been prepared in our laboratory. These new Mannich derivatives are listed in tables which follow.

Experimental

Bisphenol Intermediates

Six bisphenols were used as intermediates in obtaining these amino compounds. Three of these phenols were available commercially: (1) 4,4'-isopropylidine-bis-(2-chlorophenol); (2) 2,2'-methylene-bis-(4-chlorophenol); and (3) 2,2'-thio-bis-(4-chlorophenol). The other three were prepared in our laboratory, i.e. (4) 4,4'-dihydroxydiphenyl-2,2,2-trichloroethane; (5) 4,4'-dihydroxy-3,3'-dimethoxydiphenyl-2,2,2-trichloroethane; and (6) 2,2'-thio-bis-(4-chloro-3,5-dimethylphenol).

Each of the commercial phenols was carefully purified by recrystallization from suitable solvents to obtain reproducible melting points and these data are shown in Table I.

Phenol number 4 (Table I) was first prepared by E. ter Meer (5), and again somewhat later independely by K. Elbs (6) and H. Pauly and H. Schanz (7), by condensing phenol with chloral in the presence of concentrated sulfuric acid. We used a modification of Pauly and Schanz's method by condensing two moles of phenol with one mole of chloral hydrate in glacial acetic acid solvent, and slowly adding approximately three moles of 95% sulfuric acid at 0°C. over a two-hour period; stirring was continued at room temperature for several hours, the product washed thoroughly with water, and recrstallized from an acetone-benzene mixture. A white powder, melting at 201-2°C. was obtained, representing about 45% of the theoretical yield.

4,4'-Dihydroxy-3,3'-dimethoxydiphenyl-2,2,2-trichloroethane (phenol No. 5, Table I) was prepared from guaiacol and chloral hydrate using conditions similar to those for the preceding bisphenol. This compound was reported in 1923 by Pauly and Schanz (7).

Phenol No. 6 (Table I) was first prepared by Meadow and Reid (3), using sulfur dichloride and 4-chloro-3,5-dimethylphenol in CCl_4 at 0-5°C. We modified their procedure by using sulfur monochloride, S_2Cl_2, instead of SCl_2 which is somewhat unstable and more difficult to prepare. Otherwise, the two procedures were similar and a white crystalline product was obtained in about 30% yield, m.p. 216.5-17°C.

Mannich Derivatives

Twenty-nine new Mannich derivatives were prepared from the six bisphenols described in Table I. In general, most of these amino dirivatives were prepared according to procedures outlined by Meadow and Reid (3) and again later by O'Brien and Meadow (8), in which the bisphenol in absolute ethanol was condensed with the appropriate secondary amine in the presence of aqueous formaldehyde solution. A few of the Mannich derivatives were difficul to purify by recrystallization from standard organic solvents because of their unusual solubility characteristics; it was necessary to wash such compounds thoroughly with water and then reprecipitate the product again in water from a methanol solution. Fortunately in such cases most of the impurities could be washed out with distilled water. Further details about these compounds, including analytical data, will be found in Tables II, III, and IV.

All melting points were taken with a Fisher-Johns apparatus and are uncorrected. The analytical results on Dumas nitrogen were furnished by the Weiler and Strauss Microanalytical Laboratory, Oxford, England. Neutralization equivalents were determined in glacial acetic acid according to a method reported by Seeman and Allen (9).

Summary

Twenty-nine new amino compounds have been synthesized from six different halogenated bisphenols as intermediates. The Mannich reaction was employed to introduce various secondary amino groups. Some of these compounds are reported to have interesting physiological properties as possible carcinostatic agents (4).

Acknowledgments

Financial assistance by the Geschickter Fund for Medical Research, Washington, D.C., to carry out the synthetic chemical work on this project is very gratefully acknowledged. Some of the bisphenols used as intermediates in this work were generously supplied by the Dow Chemical Co., Midland, Michigan, and also by the Sindar Corporation, New York, New York. Samples of secondary amines, mentioned specifically in Table II, were given by the Abbott Laboratories, North Chicago, Illinois, Union Carbide Chemicals Co., New York, New York, E. I. du Pont deNemours and Co., Wilmington, Delaware, and Eastman Chemical Products, Inc., Kingsport, Tennessee. These were very much appreciated.

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Table I. Bisphenol Intermediates

Bisphenol	Melting Point °C.	Purification Solvent
1. 4,4'-Isopropylidine-bis-(2-chlorophenol)[a]	91-2	Naphtha
2. 2,2'-Methylene-bis-(4-chlorophenol)[a]	175-6	Benzene
3. 2,2'-Thio-bis-(4-chlorophenol)[b]	173-4	Benzene
4. 4,4'-Dihydroxydiphenyl-2,2,2-trichloroethane[c]	201-2 dec.	Benzene-ethanol
5. 4,4'-Dihydroxy-3,3'-dimethoxydiphenyl-2,2,2-trichloroethane[d]	75-7	Chloroform
6. 2,2'-Thio-bis(4-chloro-3,5-dimethylphenol)[e]	216.5-7	Benzene

[a]Courtesy Dow Chemical Co., Midland, Michigan. [b]Received from Sindar Corporation, New York, New York. [c]Reported by E. ter Meer(5), m.p. 202-3°; also by K. Elbs(6) and H. Pauly and H. Schanz(7). [d]Prepared by Pauly and Schanz from chloral hydrate and guaiacol. [e]Reported by Meadow and Reid(3) from SCl_2 and 4-chloro-3,5-dimethylphenol.

Table II. Di-Mannich Derivatives of Symmetrical Halogenated Bisphenols[a]

From 4,4'-Isopropylidine-bis-(2-chlorophenol)

Mannich group in each ring[b]	M.p., C.	Formula	Nitrogen, %[b] Calcd.	Found	Solvent[a]
1. Dimethylaminomethyl	139-40	$C_{21}H_{28}O_2Cl_2N_2$	6.81	6.99	Ethanol
2. Diethylaminomethyl	102-2.5	$C_{25}H_{36}O_2Cl_2N_2$	6.01	6.42[c]	Ethanol
3. Morpholinomethyl	147-8	$C_{25}H_{32}O_4Cl_2N_2$	5.66	5.82[d]	Ethanol
4. Piperidinomethyl	155-7	$C_{27}H_{36}O_2Cl_2N_2$	5.70	5.47	Ethanol
5. Pyrrolidinomethyl	96-7.5	$C_{25}H_{32}O_2Cl_2N_2$	6.05	6.01	Methanol
6. N-Methylcyclohexylaminomethyl[e]	171-2 dec.	$C_{31}H_{44}O_2Cl_2N_2$	5.12	4.94	Ethanol
7. N-Hydroxyethylpiperazinomethyl[f]	119-21	$C_{29}H_{42}O_4Cl_2N_4$	9.60	9.93	Methanol-H_2O[g]
8. N-Hydroxyethylcyclohexylaminomethyl[e]	85-90[h]	$C_{33}H_{48}O_4Cl_2N_2$	4.62	4.49	Acid-base
9. N-Ethylcyclohexylaminomethyl[e]	127-7.5	$C_{33}H_{48}O_2Cl_2N_2$	4.87	4.66	Ethanol
10. Hexamethyleneiminomethyl[i]	169-71	$C_{29}H_{40}O_2Cl_2N_2$	5.40	5.68[j]	Ethanol
11. Dimethylmorpholinomethyl[k]	173-5	$C_{29}H_{40}O_4Cl_2N_2$	5.08	5.35[l]	Ethanol
12. Derivative from AZBN[m]	222-4 dec.	$C_{33}H_{48}O_2Cl_2N_2$	5.15	4.92	Acetone

[a]All derivatives prepared as free bases and recrystallized from appropriate solvent indicated in last column. [b]Mannich group ($-CH_2NR_2$) is ortho to OH in each case; nitrogen determinations were made by micro Dumas method. [c]Neutralization equivalent on compound No. 2: Calcd., 233; Found, 236. [d]Neutralization equivalent on compound No. 3: Calcd., 248; Found, 249. [e]N-Methylcyclohexylamine, N-hydroxyethylcyclohexylamine, and N-ethylcyclohexylamine were received courtesy Abbott Laboratories, North Chicago, Illinois. [f] N-Hydroxyethylpiperazine obtained courtesy Union Carbide Chemicals Co., New York, New York. [g]Methanol 80%-water 20% by volume. [h]Melting range somewhat indefinite. [i]Hexamethyleneimine given by E. I. du Pont deNemours and Co., Wilmington, Delaware. [j]Neutralization equivalent on compound No. 10: Calcd., 260; Found, 263. [k]From 2,6-dimethylmorpholine (Eastman Kodak Co.). [l]Neutralization equivalent on compound No. 11: Calcd., 276; Found, 280. [m]This bicyclo secondary amine, 3-azobicyclo[3.2.2]nonane, was obtained courtesy Eastman Chemical Products, Inc., Kingsport, Tennessee.

Table III. Di-Mannich Derivatives of Symmetrical Halogenated Bisphenols (Continued)

Mannich group in each ring	M.p., C.	Formula	Nitrogen, % Calcd.	Nitrogen, % Found	Solvent[a]
From 2,2'-Methylene-bis-(4-chlorophenol)					
13. Dimethylmorpholinomethyl	192-3	$C_{27}H_{36}O_4Cl_2N_2$	5.34	5.07[b]	Ethanol (34%)
14. N-Hydroxyethylpiperazinomethyl	90-2	$C_{27}H_{38}O_4Cl_2N_4$	10.10	9.86	Acid-base[c] (78%)
15. Hexamethyleneiminomethyl	156-8	$C_{27}H_{36}O_2Cl_2N_2$	5.69	5.17[d]	Ethanol (15%)
From 2,2'-Thio-bis-(4-chlorophenol)					
16. Dimethylmorpholinomethyl	88-91	$C_{26}H_{34}O_4Cl_2N_2S$	5.17	5.05[e]	Acid-base[c] (48%)
17. N-Hydroxyethylpiperazinomethyl	127-8	$C_{26}H_{36}O_4Cl_2N_4S$	9.80	9.10[b]	Methanol-H_2O (52%)
18. Hexamethyleneiminomethyl	139-41	$C_{26}H_{34}O_2Cl_2N_2S$	5.51	5.83[g]	Ethanol (15%)
From 2,2'-Thio-bis-(4-chloro-3,5-dimethylphenol)					
19. Dimethylmorpholinomethyl[h]	148-50	$C_{30}H_{42}O_4Cl_2N_2S$	2.98[i]	2.88	Methanol (31%)
20. N-Hydroxyethylpiperazinomethyl	103-4	$C_{30}H_{44}O_4Cl_2N_4S$	7.75[j]	7.78	Methanol (87%)

[a]Approximate yield figures given in parentheses after recrystallization from appropriate solvent as indicated in last column. [b]Neutralization equivalent on compound number 13: calcd., 267; found, 263 (per cent nitrogen calculated on this basis equals 5.31). [c]Purification effected by extraction of free base with dilute HCl and precipitation with dilute ammonia. [d]Neutralization equivalent on compound No. 15: calcd., 246; found, 251 (% N on this basis equals 5.57). [e]Neutralization equivalent on compound No. 16: calcd., 271; found, 274 (% N on this basis equals 5.10). [f]Neutralization equivalent on compound No. 17: calcd., 143; found, 146 (% N on this basis equals 9.55). [g] Neutralization equivalent on compound No. 18: calcd., 255; found, 256 (% N on this basis equals 5.47). [h]Product obtained was a mono-Mannich derivative in this instance; neutralization equivalent results also confirm this: calcd., 471; found, 466 (% N on this basis equals 3.00). [i]Calculated on basis of one Mannich group per mole. [j]Solvated derivative; calculated on basis of 3 moles of CH_3OH per mole of Mannich compound.

Table IV. Di-Mannich Derivatives of Symmetrical Halogenated Bisphenols (Continued)

Mannich group in each ring	M.p., C.	Formula	Nitrogen, % Calcd.	Nitrogen, % Found	Solvent
From 4,4'-Dihydroxydiphenyl-2,2,2-trichloroethane					
21. Morpholinomethyl	191-3	$C_{24}H_{29}O_4Cl_3N_2$	5.43	4.97	Ethanol (35%)
22. Dimethylmorpholinomethyl	103-5[a]	$C_{28}H_{37}O_4Cl_3N_2$	4.91	4.90[b]	Methanol-H_2O[c] (90%)
23. N-Methylcyclohexylaminomethyl	194-5 dec	$C_{30}H_{41}O_2Cl_3N_2$	4.95	5.24	Ethanol (40%)
24. N-Ethylcyclohexylaminomethyl	148-9	$C_{32}H_{45}O_2Cl_3N_2$	4.70	4.76	Ethanol (30%)
25. N-Hydroxyethylpiperazinomethyl	106-8[d]	$C_{32}H_{39}O_4Cl_3N_4$	9.32	9.50	Acid-base (35%)
26. Hexamethyleneiminomethyl	148-51	$C_{28}H_{35}O_2Cl_3N_2$	5.20	5.36	Methanol-H_2O[c] (43%)
From 4,4'-Dihydroxy-3,3'-dimethoxydiphenyl-2,2,2-trichloroethane					
27. Morpholinomethyl	97-9[e]	$C_{26}H_{33}O_6Cl_3N_2$	4.88	4.47	Ethanol (60%)
28. Dimethylmorpholinomethyl	95-8[f]	$C_{30}H_{41}O_6Cl_3N_2$	4.43	4.21	Methanol-H_2O[c] (52%)
29. N-Methylcyclohexylaminomethyl	82-6[g]	$C_{32}H_{45}O_4Cl_3N_2$	4.47	4.24	Acid-base (80%)

[a]Indicates softening point; flows indefinitely between 110° and 115°. [b]Neutralization equivalent on compound number 22: calcd., 286; found, 284 (per cent nitrogen on this basis equals 4.93). [c]Purification accomplished by pouring methanol solution of free base into large volume distilled water, followed by repeated water washings. [d]Softens at 106-8° and flows slowly at about 112-4°. [e]Softening point; flows between 105° and 110°. [f]Indicates softening point; melting range at 103-6°. [g]Softening range; flows somewhat higher above 90°.

A BRIEF DESCRIPTION OF A "FERTILIZATION INHIBITOR" FROM *LYTECHINUS VARIEGATUS* (LAMARCK)

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It has been known for some time that in many species of Echinodermata forced shedding of gametes can be induced by subjecting the animal to stress with electrical shock, or by injecting 0.55 M KC1 into the perivisceral cavity (Palmer, 1937; Harvey, 1939b; Tyler, 1949). Harvey (1939a) reported that the KC1 method when used with *Arbacia punctualata* (Lamarck) often resulted in shedding of eggs which were not fertilizable, "even after repeated washings with sea water." Thus, the former of these methods is to be preferred with this organism. Forced shedding cannot be induced in *Lytechinus variegatus* by the electrical method, consequently the latter method is employed with this organism, without the ill effects mentioned above.

Since 1914, when Lillie reported a material "in the blood" capable of inhibiting the fertilization of mature eggs of *Arbacia punctulata*, there has been considerable interest in these "dermal secretions" (DS). Studies indicate that *A. punctulata* specimens liberate DS into the Surroundings when subjected to immersion in distilled water, KC1 injection, and other conditions of stress (Oshima, 1921; Metz, 1959). There have been many studies to determine the specificity of Arbacia DS (ADS) on the eggs of other echinoderms, all of which demonstrate that the fertilization-inhibiting powers are not species specific (Metz, 1960; Scheul and Metz, 1960).

It is the purpose of this paper to present a brief description of a "dermal secretion" from *Lytechinus variegatus* (LDS), which has not previously been reported in the literature, and to compare it with the ADS of *Arbacia punctulata.*

Experimental

Arbacia punctulata and *Lytechinus variegatus* specimens were taken from populations near the mouth of Alligator Harbor, Florida, and were used within seven days. All eggs were washed twice in sea water to remove the jelly layer and were carefully examined for

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maturity. Any egg samples which gave control levels of less than 98% fertilization and division were discarded.

All *Arbacia* were subjected to electrical stimulation for gamete collection, and to KC1 injection for ADS collection. *Lytechinus* specimens were treated with KC1 injection for the obtaining of both gametes and LDS, gamete shedding usually being completed several minutes prior to DS appearance.

Results and Discussion

The properties of both dermal secretions appear to be similar. As shed from the organism, they possess a yellow-green color which undergoes auto-oxidation to a deep reddish-brown upon standing, even in a nitrogen atmosphere. Such oxidation does not appear to be enzyme mediated as neither heating at 80°C., nor acid hydrolysis altered the reaction. The oxidation was not reversible with hydrosulfite. The pigments were both precipitated with trichloroacetic acid and ammonium sulfate. It is worthy of note that the oxidation state of the pigment did not significantly alter the fertilization inhibiting properties of the material (Fig. 1). Figure 2 demonstrates that the absorption of light (as determined by the "Spectronic 20") by the two dermal secretions is quite similar, both before and after oxidation.

Dialysis for 96 hours at 4°C. showed the LDS pigment did pass the membrane. Prior to dialysis the LDS samples allowed no fertilization, while afterwards an average of 61.5% (three samples) fertilization was noted. ADS pigment proved to be non-dialyzable and, there was no loss in fertilization-inhibiting power.

A certain degree of thermolability was noted for both dermal secretions following 96 hours of heating at 85°C. Those ADS samples chosen for study study allowed no fertilization before heating but showed an increase to 17% following this treatment. LDS samples were changed from total inhibition before to an average of 23% post-heating fertilization. Both inhibitors proved to be stable at sub-freezing temperatures and did not appear to lose their effectiveness after standing at room temperature for periods in excess of 100 hours.

Quantitative protein determination by the Folin-Ciocalteu and Biuret colorimetric methods gave inconsistent results, but did indicate the presence of protein in both dermal secretions. Fractionation of LDS on G-50 "Sephadex" showed that small traces of protein were present in all fractions collected, but quantities were variable. In view of this information, muramidase (Worshington), a basic protein, was tested for a possible fertilization-inhibiting capacity. Even at

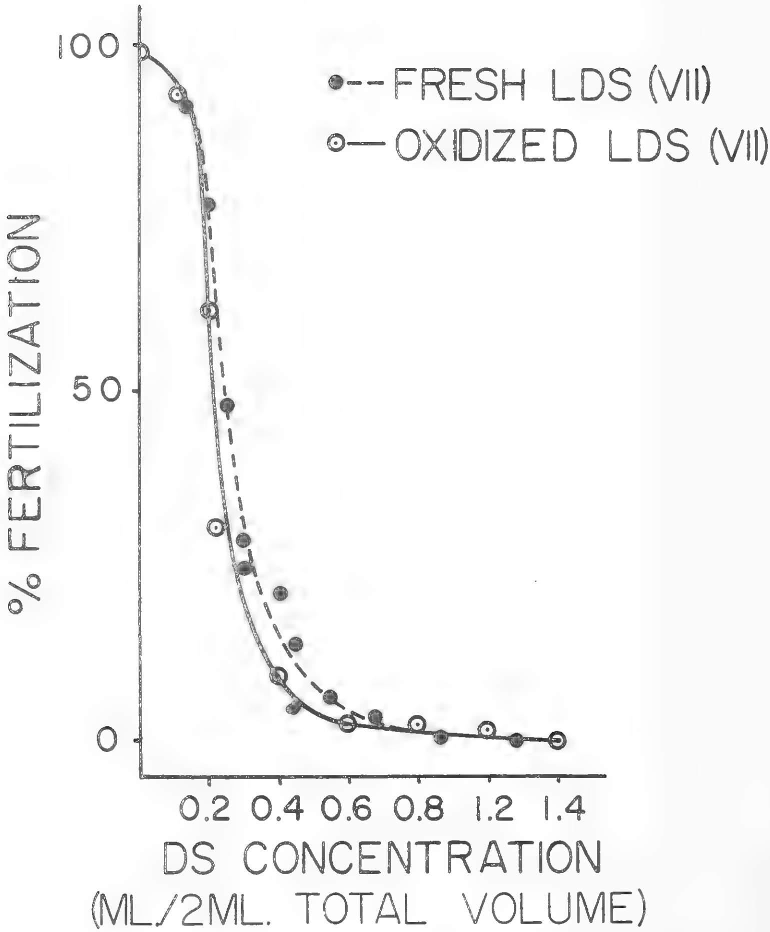

Figure 1. The effect of LDS auto-oxidation on fertilization inhibition in *L. variegatus* eggs.

concentrations of 0.09 mg. per ml. muramidase showed no ability to diminish the percentage of fertilization of either *Arbacia* or *Lytechinus* eggs.

In contrast to ADS, LDS did not display metachromasia with toluidine blue. Rather crude qualitative observations indicated that sperm of both species were stimulated by both dermal secretions, Metz (1959) attributing this property of ADS to direct action against fertilizin. In general, it was noted that both dermal secretions retarded the formation of a fertilization membrane, the elevation being both depressed and quite irregular about the egg surface. Direct microscopic examination of egg cell surfaces showed no partial discharge of cortical granules in DS treated eggs, which (it wa felt) might result in fertilization membrane depression..

The reversibility of LDS was tested by placing *Lytechinus* eggs in contact with the material for a 30 minute period, washing the eggs in sea water, then attempting fertilization. The results showed that the fertilization-inhibiting maerial could be partially washed from the egg surface. Following one washing there was an increase in fertilization of 20 to 60 per cent, subsequent washings removing no additional inhibitor. These data are in agreement with those obtained by Harvey (1939a) where the reversibility appeared to be a property of the particular lot of eggs being used. Metz (1960) noted that more sperm are required to induce the same percentage of fertilization in ADS-treated eggs and attributed this to a reduction in the quantity of "successful egg-sperm contacts." Figure 3 shows the effect of both ADS and LDS on *A. punctulata* eggs. The dependence is of an exponential type and lends support to the concept that the inhibiting

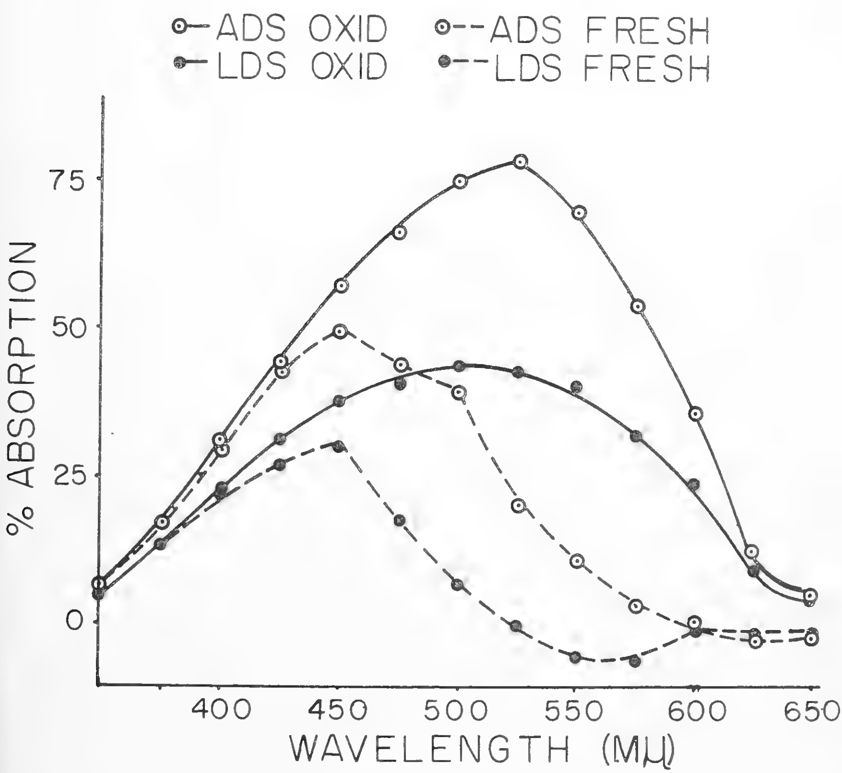

Figure 2. Light absorption by fresh and oxidized forms of ADS and LDS.

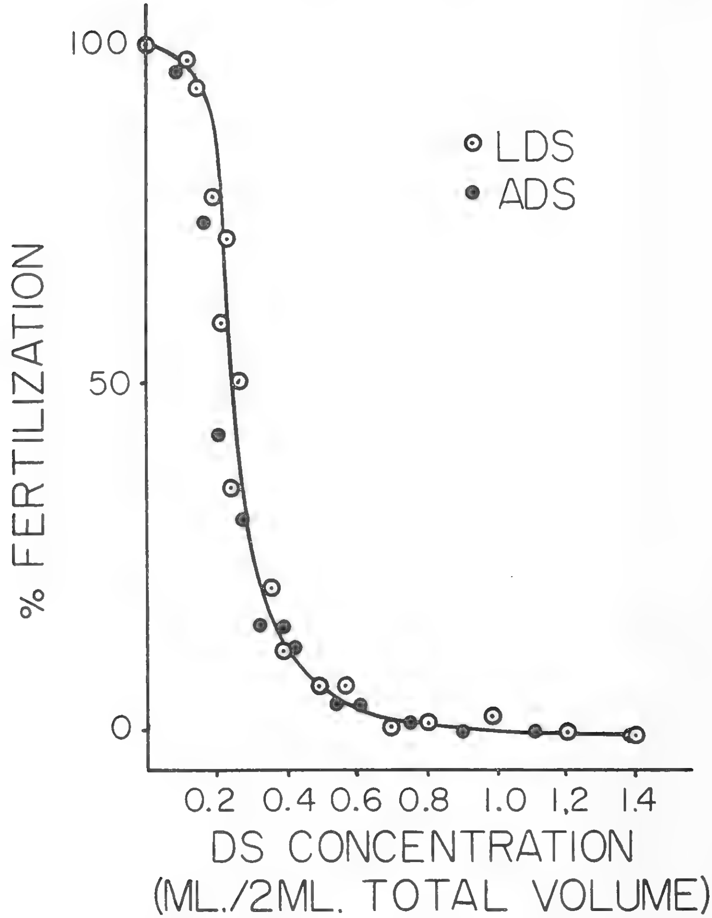

Figure 3. The effect of DS concentration on fertilization of *A. punctulata* eggs.

agent(s) of dermal secretions act competitively with sperm for specific sites on the egg surface.

Summary

A previously unreported "dermal secretion" from *Lytechinus variegatus* is described and compared with the "dermal secretion" of *Abacia punctulata.*

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RAPID MEANS OF PREPARING BLOOD AGAR PLATES

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Blood agar plates are useful tools in microbiological research because they serve as an enriched and differential medium. An enormous number of blood agar plates have been used in our laboratory to identify bacteria causing human urinary tract infections and the identification of bacteria that cause mastitis in the University dairy herd.

Blood agar plates are particularly useful in differentiating staphylococci on the basis of the type hemolysin that is produced. Rabbit and sheep erythrocytes detect alpha hemolysin, sheep cells detect beta, and delta acts on sheep, rabbit, human and horse cells. (Cowan, 1962).

Blood agar plates were made by sterilizing blood agar base (Difco), cooling to 47-50°C and aseptically adding 5% of the blood needed per liter of media. Foaming often occurred which resulted in bubbles in the poured plates. This difficulty could be avoided by brief flaming to break the bubbles. However, such flaming was time consuming and increased the chances of contaminating the plates. It was found that if one drop of Dow Corning Antifoam A (silicone defoamer) was added to 1 liter of the blood agar base, the foaming was eliminated. However, Miyasaki and Takarabe (1961) found that alpha toxin production was decreased by the addition of a loopful of antifoaming agent to a shaking culture. A check on the effect of Antifoam A showed that the growth and lysis by *Staphylococcus aureus* on blood agar was not inhibited.

The research of Hague (1967) demonstrated that the procedure used for the identification of staphylococcal hemolysins based upon their lysis pattern on various species of blood agar plates was not satisfactory. Therefore, the main value of this paper is the presentation of a rapid method in which smooth, blood agar plates can be prepared to use for isolation, recognition and enumeration of particularly fastidious bacteria.

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CENOZOIC GOLIAD FORMATION OF SOUTH TEXAS

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Introduction

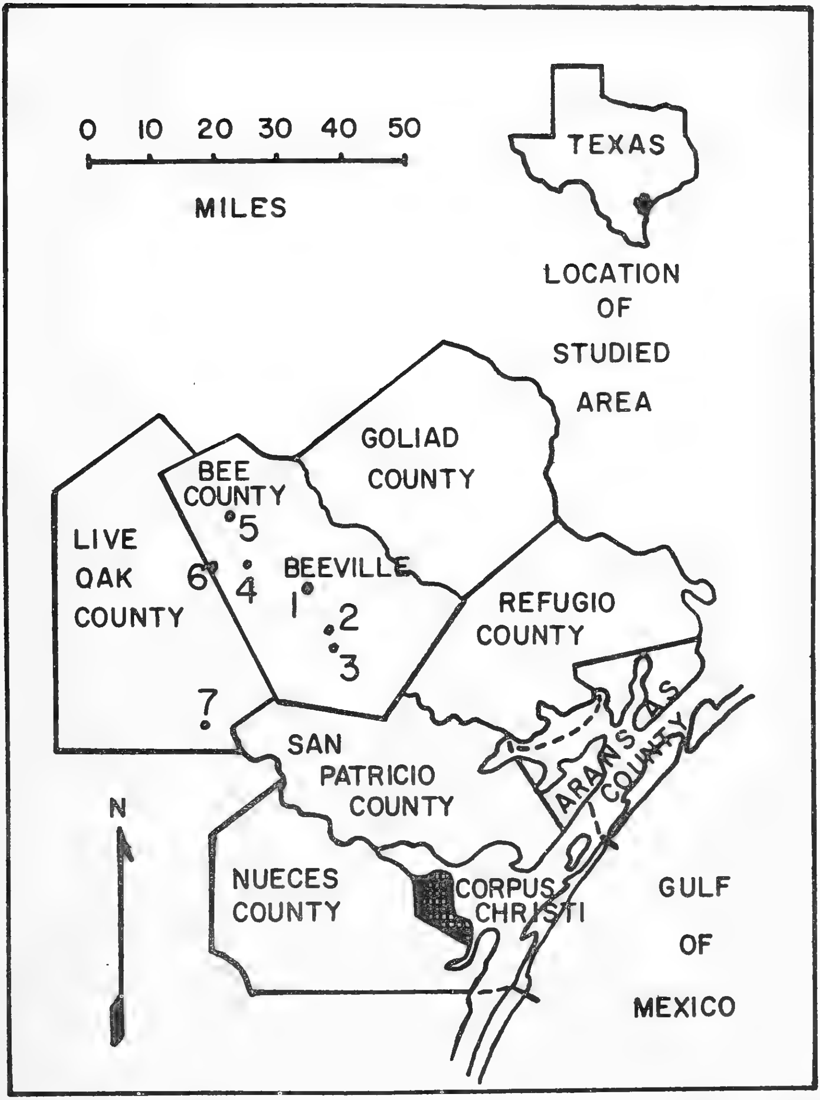
Information presented here is based on intermittent study of the Goliad Formation from 1953 to 1956, primarily in Bee and Live Oak counties, South Texas (Text-figure 1), and concerns the following aspects of the Goliad Formation: (1) the secondarily formed nodular and/or pisolitic ("algal") limestone within the Goliad caliche and its enclosed fossil land snails, (2) siliceous siltstone, a type of sedimentary quartzite, (3) seeds of the Hackberry tree, *Celtis* sp., in the upper part of the Goliad, (4) fossil freshwater mollusks and grassy plants in the Lagarto Creek Member of the Goliad, and (5) the introduction of Recent snails into the caliche of the Goliad.

Review of Stratigraphic Relationships of the Members of the Goliad Formation

Advance in statigraphic understanding of the Quaternary surface sequences of the Gulf Coast is impeded by a lack of measured sections and by a scarcity of fossils; thus, the stratigraphic placement and age of part of the Goliad Formation, and indeed the relationships of its members, are in doubt. For the purpose of this paper, we use the classification of the Goliad as accepted by Sellards, Adkins, and Plummer (1932) in which the Goliad was divided into three members in ascending order: Lapara Member (conglormerate, sandstone, and red and green clay), Lagarto Creek Member (clay), and the La Bahia Member (consisting of a lower sandstone and conglomerate, a middle marl unit, and an upper sandstone unit).

List of Localities

1. Section measured in the excavation for the basement of the Telephone Company building on Corpus Christi Street, Beeville, Bee County, Texas. Calichified sandstone and congomerate within the upper part of the Goliad.



Text—Figure 1. Location of measured sections and collecting sites in south Texas.

2. Section measured in a quarry on the east side of U.S. Highway 181 (Beeville-Corpus Christi road), 6.5 miles south of Beeville, Bee County, Texas. Caliche and nodular-pisolitic limestone boulders in the upper part of the Goliad.
3. Section measured in the quarry on the Segar Ranch, U.S. Highway 181, 7 miles south of Beeville, Bee County, Texas. Calichified

sandstone with fossil snails and hackberry seeds in the upper part of the Goliad.

4. Section measured on the crest of a hill, one mile west of Lapara Creek, on Texas Highway 202 (Beeville-George West road), Bee County, Texas. Fossil grassy plants and mollusks in the middle shaly Lagarto Creek Member of the Goliad Formation.
5. Outcrops in road cuts on Texas Highway 673, near Mineral, Texas (Beeville-Mineral road), Bee County. Silicified siltstone (sedimentary quartzite) in the caliche.
6. Outcrops in road cuts on Texas Highway 202 (Beeville-George West road) at the Bee-Live Oak County line. Siliceous siltstone (sedimentary quartzite) in the caliche.
7. Outcrops mostly of hard, conglomeratic, pebble to boulder-sized chert at Lagarto, Live Oak County, Texas.

Measured Sections

Locality 1

Pliocene

Bed		Thickness Feet	Thickness Inches
10.	Sandstone and siltstone, some clay, tan-brown in color	1	6
9.	Sandstone, with some siltstone and clay; rare, small aggregates of sandstone cemented by caliche	3	0
8.	Sandstone, in irregular contact with rare white to cream, soft caliche below; ground water deposits (stains of manganese and iron); casts and molds of small plant rootlets; lower inch or two with rare caliche	1	0
7.	Caliche, white, with irregular contact above; small pockets of dense limstone; some sandstone stringers	4	0
6.	Sandstone, tan and brown, with caliche	0	8
5.	Sandstone, medium to coarse-grained; dense limestone masses, small to large (up to 4″ x 6″)	1	0
4.	Sandstone, some lightly cemented, with limestone lenses; small, infrequent caliche nodules	2	0
3.	Sandstone and conglomerate with stringers of dense limestone	1	0
2.	Limestone lenses, with partly conglomeratic sandstone; clay stringers	3	0

1. Base of section at top of a dominantly gray-tan clay and sandstone, with dense limestone lenses; some caliche streaks	not measured	
Total thickness	17	2

Locality 2
Pliocene

Bed	Thickness Feet	Inches
8. Limstone, pisolitic, and "algal" ("algal heads" up to 26 inches in diameter); land snails, *Bulimulus* sp.	0	6
7. Caliche, some pisolitic and "algal"	0	2
6. Limestone, nodular, with caliche; irregular, weathered, upper surface with relief of a couple of inches; no snails noted	1	0
5. Limestone, like bed 4; with small orange-red clay pockets due to solution of caliche around plant roots; no snails noted	2	0
4. Limestone and caliche; molds of Recent plant roots; no snails noted	1	0
3. Caliche, as in bed 2, with some limestone stringers; no snails noted	1	0
2. Caliche, as in bed 1; with some orange-red clay pockets a few inches in diameter; no snails noted	1	0
1. Caliche, with small stringers of gray shale and limestone; no snails noted	2	0
Total Thickness	8	8

Locality 3
Recent

Bed		
5. Soil, silty, dark-brown, with some weathered nodular, limestone masses; introduced Recent snails: *Bulimulus* sp., *Helicina orbiculata tropica*, and *Polygyra texasiana*	1	6
4. Soil, light tan to tan, with some nodular limestone ..	0	4

Pliocene

3. Limestone, weathered, rubbly, and crumbled, with

solution pockets; calichified plant roots; no snails noted	3	0
2. Covered interval	1	6
1. Limestone, pebble to boulder-sized and hard; tan to brown calichified sandstone and siltstone at level of quarry floor; abundant fragmentary fossil snails in sandstone and siltstone: *Bulimulus* sp., *Polygyra* sp., and indetermined pupillids; calcined seeds of a Hackberry, *Celtis* sp., and some molds of plant rootlets	1	6
Total thickness	7	10

Locality 4
Pliocene

Bed	Thickness Feet	Inches
2. Caliche and quartz sandstone	4	4
1. Quartz sandstone and caliche limestone; paludal deposits consisting of lenses of green-gray, clayey shale in the middle part of the sandstone, with freshwater clams, snails, and grassy plants	5	7
Total Thickness	9	11

Caliche, Nodular Limestone, and Calichified Siltstone

Caliche, which occurs in west, southwest, and south Texas and northern Mexico, may be defined as a rock in which salts (mostly calcium carbonate) act as secondary cement forming quartz sandstone and siltstone (sometimes conglomeratic). In instances, the calcareous cement forms a goodly percentage of the rock; further, lenticular masses of dense limestone may be formed within the caliche. In some cases, the limestone is made up of hard pebble to boulder-sized, nodular (and in places, pisolitic masses of calcium carbonate (Plate 2, figures 2, 4, 5a, 5b). The term nodular limestone is used here for this dense, hard, nodular and/or pisolitic kind of lithology as contrasted with the ordinarily occurring, powdery (in instances also pisolitic, but soft) caliche. The terms "cap rock" and "mortar beds" are not used in this paper in describing this nodular limestone although these terms are used in the literature in describing the Ogallala Formation's hard, dense, nodular and/or pisolitic limestone of the High Plains of Texas, New Mexico, Oklahoma, Kansas,

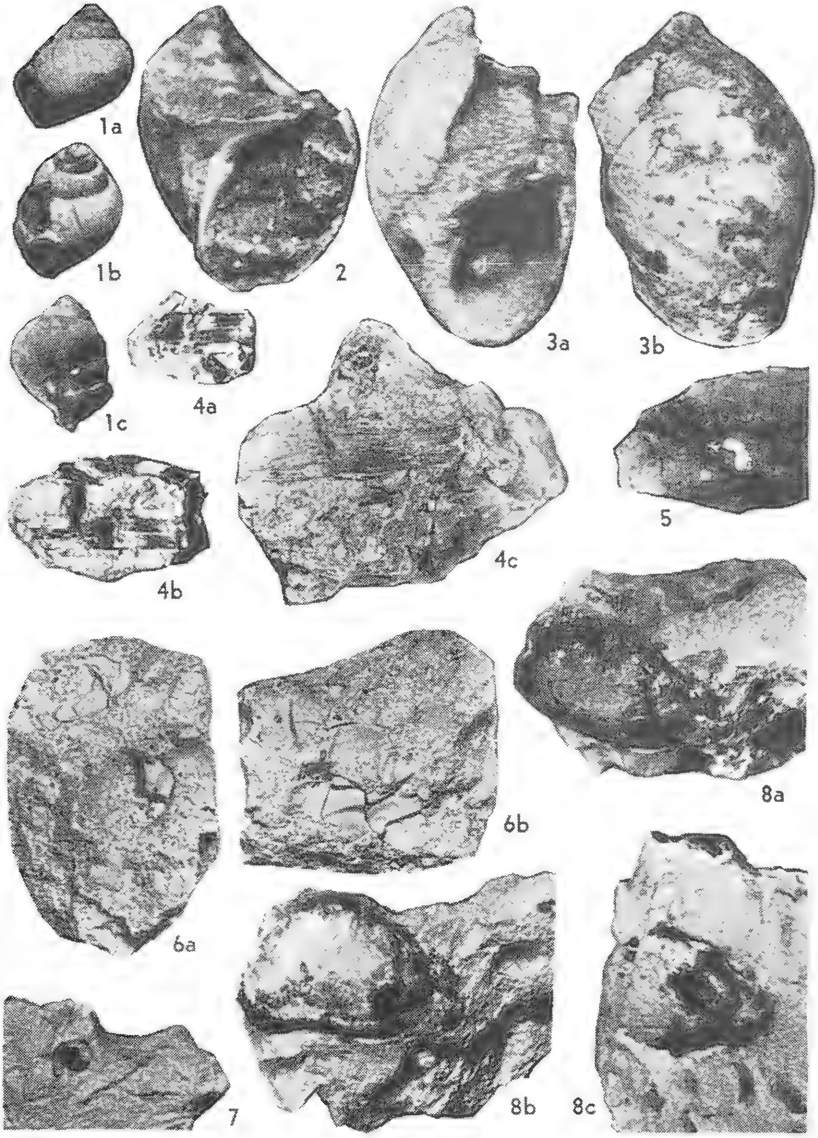


Plate 1

Iowa, and Nebraska. The term "algal limestone" also would be misleading as a term to describe this nodular limestone of the Goliad Formation for certainly little or none of it was formed in lakes; there is a general absence of freshwater fauna and flora in these nodular limestones; in addition, the limestone masses are not in bedded form.

In instances, the hard, nodular limestone masses seem to have been formed in small solution channels or in sink holes (formed during the Pleistocene and/or Recent) and the nodular limestone masses are surrounded by reddish-orange (indicating oxidation of iron compounds) calichified siltstone and sandstone; this reddish-

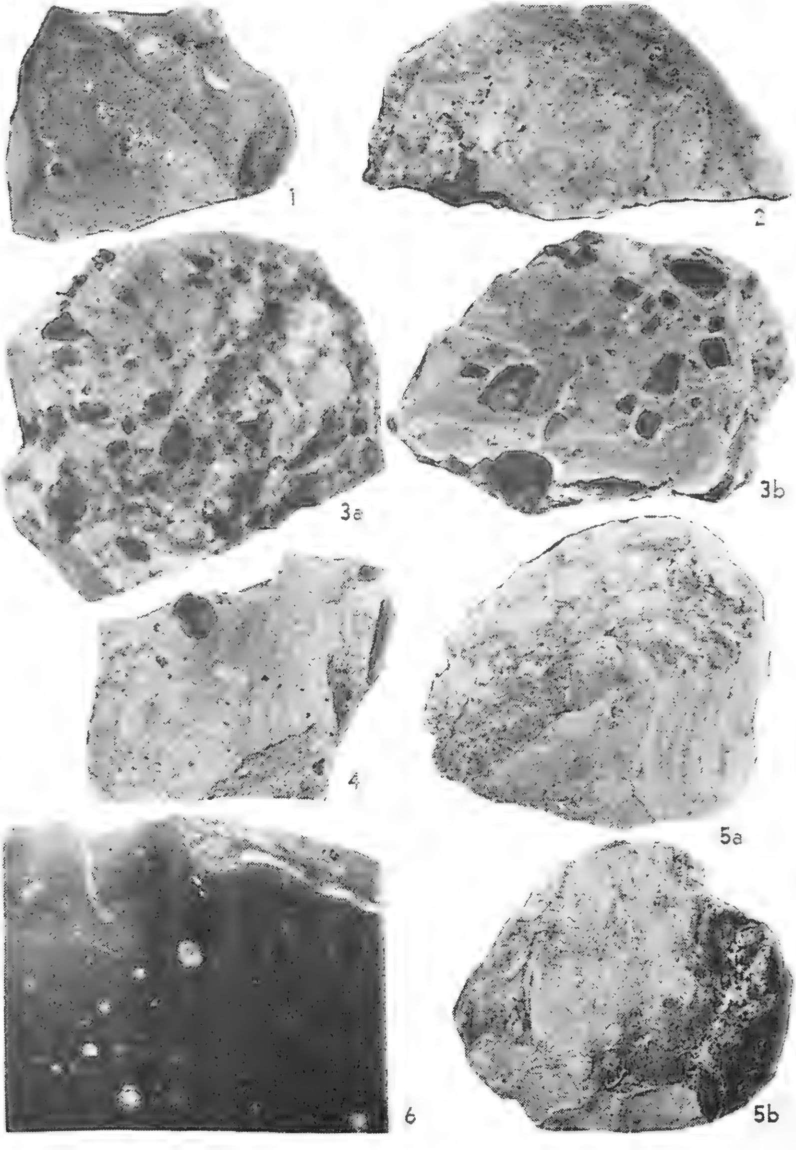


Plate 2

orange calichified siltstone occurs within the general body of ordinary whitish to buff-colored calichified siltstone and sandstone.

The Goliad deposits generally are believed to have been laid down during Pliocene time; nevertheless, much of the calcareous material impregnating and cementing the siltstone, sandstone, and conglomerates (Plate 2, figure 3a, 3b) of the Goliad must have been formed during the Pleistocene. Some calichification is still going on today in south, southwest, and west Texas, as well as in northern Mexico.

Siliceous Material in the Caliche

Siliceous material, silicified siltstone and sandstone (a kind of sedimentary quartzite) (Plate 2, figure 1), was found rarely and in scattered lenses within the caliche of the Goliad. This siliceous siltstone of the Goliad is like that which occurs in the Pliocene (perhaps in part Pleistocene in regards to caliche formation) Ogallala beds of the Llano Estacado of Texas, and the siliceous siltstones of both formations are composed of quartz siltstone, sandstone, and chert fragments with chalcedony and opal cement; molds and casts of plant roots and rootlets are present in the siliceous material and these root structures are surrounded by layers of clear white or buff-colored chalcedony (Plate 2, figure 1). Indeed, the Goliad Formation is lithologically quite similar to the Ogallala Formation of the High Plains of Texas, and the caliche and siliceous material of the Ogallala and Goliad are undoubtedly the result of similar formative processes; further, we suspect the two formations are of the same age.

Paleontology of the Goliad Formation

Fossil Land Snails

The Goliad contains various reworked fossils; specimens of reworked Miocene palm wood were found in Bee County as well as cherts derived from the Lower Cretaceous Edwards Limestone containing the tell-tale miliolid foraminiferan, *Nummoloculina heimi* Bonet, 1956 (Conkin and Conkin, 1956, 1958). Plate 2, figure 6 shows a phtomicrograph of *N. heimi* in a small piece of brown chert derived from the Edwards Limestone, but reworked into the caliche of the Goliad.

Reports of fossils indigenous to the Goliad Formation have been restricted mostly to records of scattered occurrences of vertebrates (Sellards, 1940); however, Marshall (1929) described three new genera of naiad clams and one new species of land snail, *Polygyra* *myseri*, from DeWitt County, Texas, along the Guadalupe River, about 50 miles northeast of the present localities. The materials which Marshall examined also contained some fossil horse and rhinoceras teeth which he considered indicative of a Pliocene age. Although the stratigraphic and geographic information given by Marshall (1929) is rather vague, it is probable that the fossils are from the Goliad Formation. *Polygyra myseri* is generically identifiable, but too poorly preserved to warrant the erection of a new species, or even to allow specific identification. We verify the occurrence of the genus *Polygyra* in the Goliad Formation by noting its occurrence in the quarry (Locality 3, bed 1) on the Segar Ranch in southern Bee County. Several calcined seeds of a Hackberry (*Celtis* sp.) associated with the land snails (*Bulimulus* sp. and fragmentary pupillids of indeterminate genera) were found embedded in the calichified siltstone of the upper Goliad there in the same bed. These materials were found below the surficial few feet of the Goliad caliche-limestone, in the more indurated calichified quartz siltstone and sandstone, and thus definitely are not the result of Recent introduction of land snails into the Goliad Formation, but were originally present during the time of deposition of the Goliad quartz siltstone and sandstone.

Introduced Recent Land Snails

Although there are fossil invertebrates and vertebrates indigenous to the Goliad, many of the organic remains found in the formation, particularly near the surface of the outcrops, are those of animals which were trapped in the Goliad in more recent times.

We have found the following land snails which were introduced into the surface exposures of the caliche of the Goliad during the Recent: *Bulimulus* sp., *Helicina orbiculata tropica, Praticolella berlandieriana*, and *Succinea avara*. All of these species have been reported from the Pleistocene (Wisconsinan) of the general region (Conkin and Conkin, 1961 and 1962; Conkin, Conkin, and Mason, 1962). Various stages of emplacement of Recent land snails into the caliche can be seen ranging from obvious fresh shells only slightly embedded, to slaked lime (naturally calcined) shells firmly embedded and surrounded by caliche. As a positive proot of the introduction of land snails into the caliche within historic times, we offer the discovery of fragmentary specimens of *Rumina decollata* embedded in the surficial calichified quartz siltstone and sandstone of the La Bahia Member of the Goliad Formation in the quarry behind the La Bahia Mission at Goliad, Goliad County, Texas. *R. decollata* is a Mediterranean land snail which was introduced into the United States by man within historic times. *R. decollata* attains a much larger size in the Recent of North Africa than it does in North America.

We have also observed *Bulimulus* sp. (Plate 1, figures 1a-c, 2, 3a, 3b, 5, and Plate 2, figures 4, 5a, 5b) and *Helicina orbiculata tropica* in the uppermost part of the Goliad Formation in Bee, Live Oak, and Goliad counties, embedded in the nodular limestone. It is difficult to ascertain in many instances whether these snails in the limestone boulders are contemporaneous with the deposition of the Goliad sediments or whether the snails were actually introduced during the Pleistocene. We believe, much along the lines of Trowbridge (1923), that the caliche of the Goliad was in places dissolved by sub-soil weathering and then redeposited; in instances, small solution channels were formed and the land snails were trapped in redeposited caliche-limestone which assumed a pisolitic texture so characteristic of structures formed under conditions of weathering and redeposition.

Dating by radio-carbon might be of some value in attempting to ascertain the time (if within the last part of the Wisconsinan, or the Recent) of introduction of snails into the surficial layers of the Goliad calichified siltstone and sandstone; there is, however, the problem of contamination by post-depositional radio-carbon due to ground water.

Freshwater Mollusks and Plants

Iron-stained molds and casts of fossil grassy plants (Plate 1, figures 4a-c) from the Lagarto Creek Member of the Goliad Formation occur along with casts of indeterminate naiad clams (Plate 1, figures 8a-c) and one indeterminate freshwater snail (Plate 1, figure 7) in slightly arenaceous shale to quartzose sandstone at Locality 4. The details of the outlines of the clams and snail are imperfect and ornamentation is not visible, and thus, a generic determination was not possible; however, there is no doubt that the clams and the snail are freshwater forms. Hard, dense, white to cream-colored nodules of chemically precipitated calcium carbonate (calcilutitic) occur in pockets in the calichified sandstone and in shale lenses (Plate 1, figures 6a-b). No microfossils or carbonaceous materials were observed in samples of the shale which were washed through a 150-mesh sieve.

The grassy plants associated with the freshwater clams, the snail, and the clayey shale (Plate 1, figures 6a-b), surrounded by sandstone and siltstone, indicate that the clayey deposit was formed in a very shallow body of water; the absence of carbonaceous material strongly suggests rather well oxygenated water. An ephemeral paludal environment of very limited extent, with grassy flora and a poor molluscan fauna, is indicated rather than a lake environment. The climate was no doubt semiarid (as today in this region of Texas) or arid; the extensive caliche of the Goliad gives eloquent testimony to this aridity, as does the presence of abundantly occurring semiarid to arid land snails. The occurrence of a number of vertebrate remains, particularly the teeth of small asses, indicates that the area may have been a prairie of semiarid climatic regime.

Summary

Four measured sections within the Cenozoic Goliad Formation of Bee and Live Oak counties, Texas, are presented.

Silicified siltstone, a kind of sedimentary quartzite like that which occurs in the Ogallala Formation of the High Plains, is herein reported in the Goliad.

Calichified sandstone and siltstone in the upper part of the Goliad yielded fossil land snails, *Bulimulus* sp., *Polygyra* sp., and indeterminate pupillids, and several fossil Hackberry seeds (*Celtis* sp.). Fossil freshwater clams, a snail, and grassy plants were found in a clay lens in the Lagarto Creek Member of the Goliad.

Recent land snails have been, and are being, introduced into the upper surface of the caliche of the Goliad; in one instance, *Rumina decollata*, a form introduced into North America during historic times, was found embedded in the surficial crust of the calichified siltstone.

Hard, dense, nodular, and/or pisolitic boulders of secondarily formed limestone were developed in the Goliad caliche and contain in places rather large numbers of fragmentary to whole specimens of *Bulimulus* sp.; the time of formation of these nodular limestone masses (and thus the age of the enclosed snails) is not precisely known, but is most likely Pleistocene.

Acknowledgments

Field work was done while the senior author was District Paleontologist for Union Producing Company, United Gas Corporation, in southwest Texas. We wish to express our gratitude to M. A. Peterson, District Geologist of the Beeville, Texas, office of Union Producing Company for allowing time and for making facilities available for field collecting. Assistance in the field was given by several individuals: Max Wooten, senior geologist, and Juan Sanches and Paulo Mendoza, laboratory technicians, of Union Producing Company, and Gentry Steele of Beeville.

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Explanation of Plate 1

Figs. 1a-c—*Bulimulus* sp.; X3; three views of immature specimen extracted from hard, nodular limestone; Locality 2.

Fig. 2—*Bulimulus* sp.; X2; fragment of mature specimen showing apertural view; Locality 2.

Figs. 3a-b—*Bulimulus* sp.; X2; apertural and side views of mature specimen; Locality 2.

Figs. 4a-c—Grassy plant fragments in clay; X1.1, X1.3, X1.7 respectively; three views; Locality 4.

Fig. 5—*Bulimulus* sp.; X2; small specimen in hard, nodular limestone; Locality 2.

Figs. 6a-b—Two specimens made up of a mixture of clay and quartz sandstone with chert grains; X-9; Locality 4.

Fig. 7—Clay with internal mold of an indeterminate freshwater snail; X.1; Locality 4.

Figs. 8a-c—Three views of an indeterminate genus and species of freshwater clam in clay; X1; 8a, partial side and hinge-line views of cast of right valve; 8b, side view of same specimen; 8c, internal mold of a fragment of the anterior portion of the right valve of another specimen; Locality 4.

Explanation of Plate 2

Fig. 1—Siliceous siltstone, showing plant root cavities (one near the center filled with sand and the one in the lower left quadrant partially empty, but rimmed by chalcedony); X.6; Locality 6.

Fig. 2—Sawed section of hard, nodular limestone; X.5; Locality 2.

Figs. 3a-b—Hard, nodular, and conglomeratic limestone, with pebbles of chert derived from the Lower Cretaceous Edwards Limestone to the north of the Balcones Fault Zone; 3a, natural view of specimen; 3b, polished view of specimen showing angularity of the chert and chalcedony pebbles; X.6; Locality 7.

Fig. 4—Hard, nodular limestone with Lower Cretaceous chert pebbles and a specimen of *Bulimulus* sp.; X.6; Locality 7.

Figs. 5a-b—Hard, nodular limestone; 5a, cross-sectional view of the limestone with *Bulimulus* sp.; 5b, external and weathered view of hard, nodular limestone showing concentric "algal" nodules, with some snail fragments; X.6; Locality 3.

Fig. 6—Brown chert from the hard, nodular conglomeratic limestone, showing cross-sectional views of three specimens of the foraminiferan, *Nummoloculina heimi* Bonet, 1956; chert derived from erosion of the Lower Cretaceous Edwards Limestone, north of the Balcones Fault Zone and redeposited in the Goliad Formation; X4; Locality 7.

NOTES ON THE BIOLOGY OF THE WHITE CROAKER, *GENYONEMUS LINEATUS* (Ayres)

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The white croaker *(Genyonemus lineatus)* is the most common sciaenid along the west coast of the United States. It has been recorded from San Juanico Bay, Baja California to Vancouver Island, British Columbia (Roedel, 1952), with the commercial catch records indicating the center of abundance in the Los Angeles region.

Skogsberg (1939) states that the peak seasonal abundance occurs in the months of November through March. Starks (1919) and catch records for 1953-1962 show the peak abundance to be April through June. This difference may be due to a shift in fishing effort in the years examined. Skogsberg suggests that since this species is available during all the months of the year throughout its range, fluctuations in catch (which appear independent of a shift in market demand) may be due to slight migrations between the shallow near shore waters and somewhat deeper waters farther from the coast. This contention is supported by recent commercial catch records.

Age Determinations

Otoliths have been used in this study instead of scales for age determinations because the scales were not dependable. Fewer rings were found on the scales than on the otoliths and the number of rings for an individual varied from scale to scale. Kohler and Clark (1958) found with haddock scale-otolith comparisons that the percentage of disagreeing readings increased with age and in these cases of disagreement scale ages were consistently lower than otolith for practically all ages in certain areas of their study.

Otoliths were dissected from 446 fish, wiped clean, then stored in glycerin in 6 x 50 mm culture tubes numbered serially. The otoliths were prepared for examination by placing them distal surface upward in a watch glass and covering them completely with fresh glycerin. Summer zones were counted on the left portion of the otolith under a low power (10x to 50x) "zoom" dissecting scope with reflected illumination. Otoliths were collected in July and August of 1963 from Long Beach Harbor (Table 1).

In an attempt to validate age determinations, age groups obtained by otoliths and those obtained from a Petersen (1892) length frequency distribution were compared (Table 1). Age groups 0–IV and VII–XII

Table 1. Average Standard Length and Range of The White Croaker by Otolith Age from Long Beach Harbor, July and August 1964 Compared to Class Interval Peaks of a Petersen Length Frequency Plot

Age Group	Number	Average Length (mm)	Size Range (mm)	Petersen Class Interval Peaks
0	26	45	32-57	43-47
I	98	72	45-95	68-72
II	10	120	113-123	118-122
III	40	145	131-159	143-147
IV	64	163	141-175	163-167
V	70	184	160-205	183-187
VI	42	195	178-211	193-197
VII	40	208	185-228	208-212
VIII	22	217	202-232	213-217
IX	12	225	210-232	223-227
X	8	234	223-238	233-237
XI	6	250	246-256	248-252
XII	6	263	259-267	263-267
XIII	2	271	271	271

compared exceptionally well. Age groups V and VI are slightly out of phase and since there are only two specimens in age group XIII its placement is tenuous at best. A growth curve formed from this data indicates rapid growth from the zero to age group V tapering off to a steady but somewhat slower rate of growth in the rest of the years. Age groups XI-XIII show a jump in growth rate which probably reflects the small sample size and the fact that older fish present considerable difficulty in aging.

Size at Maturity

Fish were sexed and measured when material was available. Standard lengths were measured to the nearest millimeter. From June 1963 to April 1964, 2005 measurements were made.

Fish were designated as immature, mature, or spent. Females were classified as immature if no eggs were visible in the ovary, males when the testes were small. Spent fish were those with flaccid bloodshot gonads. Maturing females had visible eggs and maturing males had whitish testes.

The white croaker matures between 147 and 164 mm standard length at an age of 3 to 4 years. Spawning occurs between November and May with peak activity in January through March.

The commercial fishery consists of fish ranging from 139 to 273 mm standard length with the bulk of the catch falling between 164 and 223 mm. Practically the entire catch consists of adult fish or fish approaching their first spawning season.

Distribution in Time and Space

Commercial catch records for 1953 to 1962 reveal that peak catches of white croaker occur in different months for the various statistical catch areas used by the California Department of Fish and Game to tabulate the commercial catch along the California coast (Table 2).

Table 2. Per Cent of Commercial Croaker Catch by Month for the Ten Year Average of 1952 to 1962

Month	San Francisco	Monterey	Santa Barbara	Los Angeles	San Diego	Fort Bragg
January	2.6	1.9	3.1	17.2	4.6	
February	2.2	5.2	9.1	5.8	2.5	
March	1.7	6.2	13.4	8.2	3.3	
April	3.6	12.1	17.6	11.5	1.0	
May	5.5	9.2	15.4	17.8	2.4	
June	10.6	12.0	1.3	9.2	4.9	
July	19.2	9.8	5.6	5.1	6.5	100.0
August	12.7	12.3	6.9	4.5	26.4	
September	23.7	12.2	8.4	3.6	26.9	
October	9.3	11.3	10.1	2.4	10.2	
November	3.7	5.4	7.5	6.1	7.0	
December	5.2	2.2	1.5	8.6	4.1	

Beginning in March, peak commercial catches are recorded in Santa Barbara, April in Los Angeles and Monterey, June in San Francisco, July in Fort Bragg, and August in San Diego. It is postulated that there is a slight offshore migration as suggested by Skogsberg during the non-peak months and that this migration coincides somewhat with the spawning time. However, ripe individuals are found in all locations throughout the spawning season.

Testing of blood samples of white croaker with Hyland Laboratories blood grouping serum Anti-B by the slide method indicates population heterogenity between groups of fish from different areas. Two of 100 fish tested from the entrance of Long Beach Harbor reacted positively and 40 of 50 fish tested near Treasure Island in San Francisco Bay also showed a positive reaction.

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VALLEY CENTIPEDES (CHILOPODA; SYMPHYLA) FROM NORTHERN KENTUCKY

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The Cumberland Mountains of Kentucky represent, in part, some of the oldest undisturbed habitat in North America. This is especially evident in the myriadal complex of small valleys that mark the system. However, as coal maning, deforestation and damming practices continue many of these relict areas are going by the board, or are being so badly disturbed that in a few years only traces of them will remain.

In this connection, the authors have begun a long-term ecological and systematic study of the Red River Drainage of northern Kentucky in order to secure at least a degree of information concerning the flora and fauna of relict-versus-disturbed areas within the total region. Particularly instructive have been some tributary canyon systems of the North Fork of the Red, lying in Wolfe and Powell counties. We have carried out several studies in this area, one of which concerns ground-dwelling invertebrates, special emphasis being given to the Chilopoda, Diplopoda, Arachnida and Mollusca. The remainder of this paper will treat the centipedes. The 172 specimens collected represent two classes, four orders, 10 families, 16 genera and 22 species. One centipede order, four families, four genera and six species are added to the known fauna of Kentucky.

Study Area

The canyon systems under consideration head approximately four-fifths of a mile northwest of Pine Ridge, Wolfe County, Kentucky, (Map 1.). They are associated with Tight Hollow Creek, Mill Creek and the Middle Fork of Red River, the latter lying in Powell County. The Tight Hollow System encompasses 0.558 of a square mile; Mill Creek drains 2.343 square miles. The Tight Hollow System is three-pronged, roughly y-shaped, the south arm of the Y also having a short, deep bifurcation.

The south arm heads at 1,040 feet mean sea level (MSL), and extends 2.4 miles to its confluence with the northern arm. The cliffs

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* Supported by Eastern Kentucky University Faculty Grant 5-3-372-6.

at the head are of sandstone and are slightly more than 200 feet high, vertical and concave. Below this the cliffs are of varying altitude, but all steep, the valley between narrow and rocky.

The northern arm heads at 1,240 feet MSL and makes contact with the southern arm at 1,030 feet, approximately two miles below its origin. The topography is similar to that of the southern arm. Below the confluence, the lower arm extends 2,225 feet to make contact with the Mill Creek Canyon at 900 feet MSL. From this point, the Canyon meanders between steep walls for 12,000 feet to make contact with the wide canyon of the Middle Fork of the Red River, at approximately 800 feet MSL, in Powell County, picking up the small canyons of Doe Branch, Black John Creek, and Double Cave Branch, all of the latter being similar to Tight Hollow.

Generally speaking, the whole region is of a mixed mesophytic nature. The dominant trees in the area are *Betula lenta* Linnaeus, *Tsuga canadensis* Carr, *Liriodendron tulipifera* Linnaeua, *Acer rubrum* Linnaeua, *Cornus florida* Linnaeus and *Magnolia fraseri* Walt. On the southern ridges *Ilex opaca* Ait., from station 6 upgrade, is abundant. At the upper ends of the canyons, for stations 1 through 5, *Rhododendron maximum* Linnaeus is exceedingly dense, up to 2117 main stalks per acre being encountered. Below station 5 this plant is progressively replaced by mountain laurel. This same relationship is also expressed in hemlock versus white and Virginia pines, hemlock being displaced by the latter. This is a reflection of logging. Station 1 through 5 represents relict areas; all of the stations below 5 have been variously disturbed by farming, deforestation and some rather insignificant silver mining.

Collecting Stations

Fourteen localities were visited, and these are shown on map 1 and described below. The limits of each station are demarked by arrows. For the purpose of securing invertebrates a swath-transect, set at right angles near the center of each station, was followed from hill crest to hill crest.

Station 1. 26 February 1966. Valley narrow with vertical cliffs, old talus slides, sandstone, numerous fallen trees; dense vegetation, moss, ferns, liverworts; much seepage.

Station 2. 5 March 1966. Sides of valley steep, v-shaped in transect, wider at head; many flat sand stones; considerable topsoil (washed in from above); vegetation as in station 1.

Station 3. 12 March 1966. Valley slope gentler, u-shaped; much organic debris; vegetation as in station 1.

Station 4. 19 March 1966. Valley floor flat (about 100 feet wide); gravel and sand, large and small sand rocks, deep litter.

Station 5. 26 March 1966. Like station 4.

Station 6. 2 April 1966. Valley much wider, walls less abrupt; numerous springs; *Tsuga* partially replaced by white pine and *Rhododendron* by *Kalmia* (because of old deforestation).

Station 7. 9 April 1966. Similar to station 6, but valley resumes its v-shape, steep sides; much ironwood, maple; practically no *Rhododendron;* large boulders, rubble, dead logs.

Station 8. 23 April 1966. Mill Creek Valley; wide, moderate slope; fairly flat floor; much evidence of forestry and agriculture; floor with grass, *Lobelia,* willows, sumac, weeds, dogwood; some boulders and stones, rubble and organic debris.

Station 9. 14 May 1966. Similar to station 8, but walls less steep; flood plain grassy with much sand siltation; some old mine diggings.

Station 10. 22 May 1966. Similar to station 9, but valley wider.

Station 11. 25 June 1966. Valley partially filled by Mill Lake impoundment; many dead trees, standing and fallen.

Station 12. 11 June 1966. Middle Fork of Red River Valley. Valley wider, flood plain flat, under agriculture, old field (tobacco and corn); willow, sycamore, tulip tree, hawthorn, few evergreens.

Station 13. 12 July 1966. Valley wide, flood plain about 80 feet wide; weeds, dead leaves, flat sandstones; vegetation as in station 12.

Station 14. 9 July 1966. Similar to station 13, but bank of stream with much kudzu.

Annotated List

In the list which follows the specimens collected are referred to the collection stations by number. The figures in parentheses which follow the station designation represent the number of specimens collected.

Because so little is known concerning Kentucky centipedes, brief descriptions of those collected are given in order to facilitate additional study by other workers. All measurements are in mm.

Order Geophilomorpha

Centipedes with simple eyes or eyes entirely absent, lateral tracheal pores, more than 23 pairs of short legs (slightly longer than width of body) and antennae shorter than length of body. Three families now known from Kentucky.

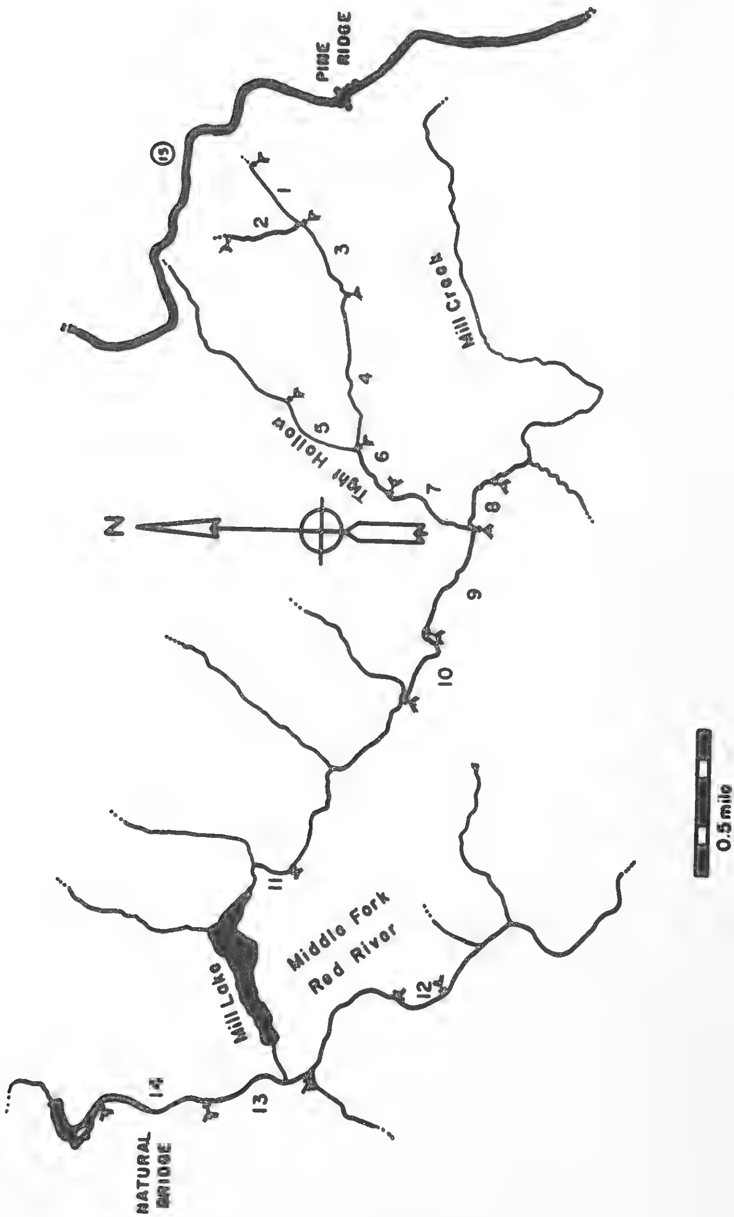

Figure 1. Showing the location of collecting stations in Wolfe and Powell counties, Kentucky. See text for details.

Family Geophilidae

Members of this family possess poison claws which bear small or large denticles basally and either lack pores in the sternites or have them arranged in fields in the center of each sternite. Four genera and seven species reported from Kentucky. Our collection disclosed two genera and four species.

Geophilus ampyx Carbill

Station Records: 13 (1); 14 (1).

Bright red in color, slender, with more than 67 pairs of legs, a narrow terminal plate and the last legs bear claws. Secured from decaying logs. Our failure to secure this species in the narrow head-water valleys, in light of what few records there are for this species in Kentucky, seems to indicate a preference for low altitudes with considerable moisture. Classed as uncommon.

Geophilus varians McNeill

Station Records: 1 (1); 2 (2); 3 (2); 5 (2); 6 (2); 8 (1).

Body yellow, head reddish-brown, last 2-3 segments brown, caudal filaments dark; 57-66 pairs of legs, measurements; total length, 35.8 (31.0-43.0); greatest width, 1.4 (1.0-1.6); length antennae (14 segments), 3.2 (3.0-.5); length caudal filaments, 2.5 (2.5-2.5); width caudal filaments, 0.25; number of body segments, 73 (59-87). No apparent altitudinal preference. Found under rocks, forest litter and decaying logs, with a preference for the latter. Classed as moderately common.

Geophilus vittatus (Rafinesque)

Station Records: 9 (1).

Yellowish-brown in color, head darker than body; posterior edge of segments bears diamond-shaped marks; legs lighter than body; body moderately depressed; 52 segments behind head, the last one smoothly rounded behind; caudal filaments short, their segments inflated. Total length 34.5; width, 2.0; length caudal filaments, 2.0. Found beneath a large stone. Classed as uncommon.

Arctogeophilus umbraticus (McNeill)

Station Records: 4 (3); 5 (1); 7 (1); 9 (2); 10 (2); 12 (1); 13 (2); 14 (2).

Body yellow, moderately depressed, head dark, antennae segments barrel-shaped, tapering distally; poison claw long, not inflated. Measurements and counts: total lengths, 38.5; width, 1.5; length of antennae, 3.0; antennae segments, 15; body segments behind head, 45. Another species of the middle and lower stretches of valley systems, usually under decaying vegetation, logs and rocks. Common.

Family Dignathodontidae

Centipedes with filiform or moderately clavate antennae, mandibles bearing a single pectinate lamella, a deeply cleft labial sternum, small anal pleurae, and 55 to 155 pairs of legs. One genus and five species known from Kentucky. Our collections included specimens of three species.

Strigamia bidens (Wood)

Station Records: 1 (2); 4 (1); 7 (1); 8 (1).

Body blood red to purplish red, long and slender; legs short, lighter than body; antennae slender, beaded; caudal filaments slender. Counts and measurements: length, 42.9 (35.2-50.5); width, 2.0; length antennae, 2.7 (2.3-3.0); length caudal filaments, 1.5; width caudal filaments, less than 0.5; 67 (63-71) body segments. Decided preference for decaying wood. Probably common.

Strigamia branneri (Bollman)

Station Records: 1 (1); 2 (1); 3 (2).

Very similar to last species. Body lighter in color, a tendency toward pinkness; head red, legs yellow. Length, 23.5; width, 1.0; antennal length 1.5. Found under decaying logs.

Strigamia bothripa (Wood)

Station Records: 7 (1); 14 (2).

Found with *S. Branneri.*

Family Schendylidae

Centipedes with filiform antennae, mandibles with one pectinate and one to three dentate lamellae; labial sternum uncleft or convex, often with a process; 39 to 72 pairs of legs. Heretofore unknown from Kentucky. We report one species.

Escaryus urbicus (Meinert)

Station Records: 1 (1).

Body, antennae and legs yellowish-white; head reddish-brown; last sternites narrow; poison claw smooth; antennae extends back about six and one-half body segments; body length 21.0; width 1.0; 41 pairs of legs. Found under a pile of decaying twigs.

Order Scolopendromorpha

Centipedes with only pigmented eyespots, a few ocelli, or eyes lacking, and 21 to 23 pairs of short legs. Two families, Scolopendridae and Cryptopidae, known from Kentucky. All of our specimens belong to the latter taxon.

Family Cryptopidae

Members of this family lack ocelli, although pigmented eyespots are sometimes present. Three genera and four species known from Kentucky, all are represented in our collections, plus one addition to the known fauna.

Cryptops hyalina (Say)

Station records: 6 (2); 10 (1); 11 (1); 12 (1).

Body pale yellow, head and antennae slightly darker, legs lighter; 17 antennal segments bead-like, the last one larger than those preceeding it; caudal filaments, about 17.0 X 0.5, quite heavy, bearing a double row of stout, reddish bristles on the median surface, the ventral bristles even heavier; final body segment smoothly arcuate; 22 body segments. Measurements: length 9.5 (8.5-10.5); width, 1.0; length antennae, 1.8 (1.5-2.0). Invariably under deeply placed rocks. Our records indicate this to be a form of the wider systems, lower in the valley, probably because of prevailing moisture considerata.

Theatops postica (Say)

Station Records: 5 (1); 7 (2); 8 (5); 9 (1); 10 (1); 11 (2); 12 (2); 13 (1); 14 (1).

Body bright yellow to lengths of 30.0 mm, beyond that becoming progressively darker, to light horn; no eyes or pigmented spots; poison clay strong; 21 pairs of legs and 21 segments behind the head; last segment of body abruptly enlarged, truncate fore and aft; antennae relatively long, tapered, with 17 segments beyond the pedicel; caudal filaments, short, depressed, very broad, crossed at the tips, with five segments, excluding the claw. Found under decaying logs. See chart below for measurements.

Length	Width	Length Antennae	Length Caudal Filaments	Width Caudal Filaments
13.0	1.6	3.5	2.5	0.5
20.0	2.0	7.2	2.8	1.5
22.0	2.0	5.5	3.0	1.5
30.5	3.0	6.0	3.3	1.5
33.0	2.5	6.5	3.5	2.5
33.0	2.5	6.5	2.7	1.5
38.0	3.2	7.4	3.0	1.6
38.5	2.0	7.2	2.8	1.5
43.0	3.0	7.5	3.5	1.5
		Averages		
30.1	2.4	6.0	2.9	1.5

Scolopocryptops sexspinosa (Say)

Station Records: 1 (2); 4 (1); 5 (3); 6 (1); 7 (1); 8 (4); 10 (1); 11 (1); 13 (2).

Body metallic-brown in immatures, yellowish-horn, red-mahogany or reddish-brown in adults; 23 segments and 23 pairs of legs; terminal segment with a broad, tongue-like postero-median projection between caudal filaments; caudal filaments long, moderately stout, five segments, the basal one bearing a sharp spur on its median edge near the center; antennae tapered, 18 segments. Common under rotting logs.

Length	Width	Length Antennae	Length Caudal Filaments	Width Caudal Filaments
34.5	3.0	13.5	--	--
39.0	3.7	6.2	6.0	--
40.0	3.0	8.0	9.5	1.0
53.5	4.5	9.0	10.0	0.8
		Averages		
41.8	3.6	9.2	8.5	0.9

Scolopocryptops nigridia (McNeill)

Station Records: 1 (1); 4 (5); 5 (14); 6 (6); 7 (3); 8 (3); 9 (3); 10 (5); 11 (1); 12 (2); 13 (3); 14 (3).

Body, depressed, coloration ranges from white (at 12.5 mm) through yellow and yellowish-brown to reddish-brown; head yellowish-red; legs light yellow; 23 segments, the last one bearing a slender spine on either side and a narrow, tongue-like elongation of the scutum, or the latter lacking; antennae tapered, their 17 segments bead-like; caudal filaments long, moderately heavy, 5 segments; poison claws heavy, inflated basally, folded beneath head. The most common species encountered; under decaying logs and leaves.

Length	Width	Length Antennae	Length Caudal Filaments	Width Caudal Filaments
10.3	1.0	3.2	3.2	2.5
12.3	1.5		4.5	
12.5	1.4			0.25
13.0				
20.5	2.0	4.0		
21.0	2.5	2.3		
21.0	2.2	5.2		
21.5	2.5	4.5	6.5	0.5
25.5	2.5	4.0	5.6	0.5
27.0	2.0			
28.0	3.0	3.5	5.5	
33.0	3.0	3.5		
		Averages		
19.6	2.1	3.8	5.1	0.37

Scolopocryptops gracilis peregrinator (Crabill)

Station Records: 7 (2).

Yellowish-horn to horn in coloration; length 21.5; width 2.5; very slender antennae, 3.5 in length; caudal filaments 6.5 in length, 0.5 in width. Found beneath decaying leaves. A new record for Kentucky.

Order Scutigeromorpha

Centipedes with long, angular legs, large compound eyes, and antennae nearly as long as the body. Heretofore unreported from Kentucky. One family, genus and species.

Family Scutigeridae

With the characters of the order.

***Scutigera coleoptrata* (Linnaeus)**

Station Records: 11 (1).

Smokey-gray in coloration; body (18.5 X 3.0) tapers posteriorly, but widest at next to last segment; legs very long (24.0), their femora bearing two long, stout spines disto-dorsally, and one subterminally on the ventral surface; patellae long, bearing three spines; oral palps bear seven long, stout spines; antennae long (19.5), whip-like, each segment being elongated and annulated; eyes large, black at angles of head; with eight scutes, notched posteriorly. Secured from an outdoor bath house. This species (sight records) is widespread in various buildings.

Order Lithobiomorpha

Centipedes with simple eyes composed of a few ocelli, or these lacking; short antennae and 15 pairs of short legs. Until now only two families have been recorded from Kentucky, Lithobiidae and Ethopolidae (Crabill, 1955). Two additional families are herewith recorded, Gosibiidae and Henicopidae.

Family Ethopolidae

Centipedes lacking spines on the cephalodistal ends of the tibiae and possessing wart-like gonopods in the male and bifurcated, claw-like ones in the female. Two genera and species known from Kentucky; one represented in our collections.

***Bothropolys multidentata* (Newport)**

Station records: 1 (2); 2 (1); 4 (2); 5 (1); 6 (2); 8 (1); 14 (1).

Body coloration variable, dark reddish-brown, metallic-bronze to nearly black; venter yellowish to uniformly yellowish-gray in female, darker in the male; poison claws yellow to dark brown, their spine dark brown; 15 to 17 body segments; antennae with 20 to 21 segments, tapering; caudal filaments relatively heavy, ending in posteriorly directed, triangular spines; legs short, hardly as long as width of body, spiny, dark; last segment truncate, without spines. Common under rocks and decaying leaves.

Length	Width	Length Antennae	Length Caudal Filaments
19.0		10.0	9.0
20.0	3.0	10.5	9.0
20.0	2.5	8.5	
21.0	3.0	9.5	10.0
22.5	3.0	11.0	
26.0	3.0	11.0	10.0
	Averages		
21.4	2.9	10.1	9.5

Family Henicopidae

Centipedes possessing a sharp spine on the cephalodistal ends of the tibiae, except on the first three pairs of legs. One species reported here for the first time.

Zygethobius pontis (Chamberlin)

Station Records: 9 1); 11 (1); 13 (2).

A small, grayish-white centipede with 15 segments behind the head, the terminal one being much narrower than those in front of it and bluntly truncate; one pair of large, prominent ocelli present; length 5.5, width 1.0, antennae 4.0 in length, 25 segments. Found in the moister, lower stretches of the valleys.

Family Gosibiidae

Centipedes with simple (smooth) gonopods, or gonopods lacking, and 20 segments in the antennae. Characteristics otherwise as in the order. One species reported here for the first time.

Arenobius manegitus (Chamberlin)

Station Records: 1 (2); 7 (3).

Metallic-grayish-blue or brownish; segments margined by gray, laterally blue-gray, venter lighter; antennae equal to seven or eight body segments in length, 20 segments; body length 15.0. Found beneath decaying leaves.

Family Lithobiidae

Centipedes in which the male gonopods are small, wart-like. Nine genera and 14 species heretofore reported from Kentucky (Crabill, 1955). An additional two species, *Garibius pagoketes* Chamberlin and *Paitobius zinus* (Chamberlin), are here recorded.

Garibius pagoketes (Chamberlin)

Station Records: 9 (1); 12 (1).

Brownish-yellow centipedes with 20 antennal segments. Found under decaying logs and leaves.

Nadabius pullus (Bollman)

Station Records: 2 (1); 5 (3); 13 (1).

Light tan to purplish-brown; three rows of small ocelli; 16 to 17 segments behind the head; antennae tapered, with 20 segments, 3.0 to 5.0 long; legs longer than width of body, the last three coxae bearing lateral spines; caudal filaments slightly flattened; total length, 8.0 to 12.0; width, 1.0 to 2.0; antennal length, 3.0 to 5.0 Found under rocks, decaying logs and leaves.

Sozibius tuobukus (Chamberlin)

Station Records: 1 (4); 7 (3); 10 (2); 13 (1).

Whitish-yellow to light brown dorsally, nearly white to light tan below; tergites not produced; about 15.0 in length; antennae about one-third length of body, 25 segments. Found under decaying logs.

Sozibius species

Station Records: 6 (1).

Either an undescribed species or an aberrant example of *S. tuobukus*. Yellow, depressed; 16 segments behind the head; antennae long, slowly tapering, the 25 segments bead-like; terminal body segment about as wide as long, truncate, bearing a strong, curved spine on each lateral surface; caudal filaments 3.3 in length; body 9.5; width, 1.5 Found beneath a decaying log.

Paitobius zinus (Chemberlin)

Station Records: 12 (1); 13 (1).

In general appearance like *Nadabius pullus,* but in this species tergites are strongly produced on at least the last four segments. Under decaying vegetation and logs.

Class Symphyla

Small, white myriapods with long slender antennae, usually 15 body segments, genital openings near the anterior end, and a well-developed head. One species here reported from Kentucky for the first time.

Scutigerella immaculata (Newport)

Station Records: 1 (4).

Whitish-yellow, about 9.0 mm in length; antennae one-third length of body, constantly moving. Although specimens were collected only at station one, sight records were made at all others. Found under moist humus, decaying vegetation and broken rubble.

Acknowledgment

We are indebted to Dr. Andrew A. Weaver, Wooster College and Harvard University, for identifying all specimens, for helpful comments, and for his uncommon interest.

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Membership in the Kentucky Academy of Science is open to interested persons upon nomination, payments of dues, and election. Application forms for membership may be obtained from the Secretary. The Transactions are sent free to all members in good standing.

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VARIATION IN SIZE AMONG ADULT *EPTESICUS FUSCUS*

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An unexpected availability of a large sample of adult big brown bats (*Eptesicus fuscus*) led us to study the size variation in these animals. We decided to measure the range of variation, evaluate sexual dimorphism, and determine what measurements are least variable, and thus are the best to use in determining relative sizes in a sample of bats.

On 30 June 1964 a commercial pest control organization gassed the bats in the Baptist Church at Midway, Woodford County, Kentucky. Workmen gathered the dead animals and brought them to Lexington. Upon being notified by the company, we recovered the bats and stored them in a plastic bag in a freezer. They were later thawed and examined. The group consisted of both adults and juveniles. We separated out the juveniles and studied only the adults. Although some juveniles were nearly as large as the adults, all were easily recognized by their dark pelage and open epiphyses.

Standard measurements of total length, length of the tail, and length of the forearm were taken from each bat. Total length and tail length were measured with a ruler to the nearest mm. Forearm length was measured with a dial caliper and read to the nearest 0.1mm. This measurement was the greatest length of the forearm of the folded right wing. It includes the carpals and the thickness of the skin as well as the length of the ulna. Body length of each bat was obtained by subtracting the length of the tail from the total length. Mean values and standard deviations were calculated for each sample for each measurement. Because the masurements taken differ considerably in magnitude, the coefficients of variation V=100 S.D./mean were calculated for each measurement to aid in comparing variablilities of the different measurements. The sexes were compared by z-tests.

Data obtained from the 92 adult females and 32 adult males are summarized in Table 1 and in the figures. Measurements were rounded to the nearest mm for constructing Figure 3.

Females are significantly larger than males in all measurements taken, except length of the tail. Phillips (1966) found measurements of total length, wingspread, length of skull and breadth of zygomatic arch to be significantly larger for females. Engels (1936) found that adult females averaged 4 to 5 per cent larger than males. The least variable measurement among the females was the length of the forearm. The variation in total length and body length are only slightly greater. The data for males are not as reliable because of the much smaller sample size, but they suggest total length and forearm as the least variable. In both sexes length of the tail shows high variability.

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Table 1. Measurements of *Eptesicus fuscus*

	FEMALES				MALES			
	No.	Mean	S. D.	V.	No.	Mean	S. D.	V.
Total Length	92	122.3	4.480	3.65	32	115.5	2.810	2.03
Tail	92	45.8	2.837	6.19	32	44.9	2.487	5.53
Body	92	76.4	3.024·	3.96	32	67.0	4.230	6.20
Forearm	92	47.8	1.433	3.10	32	46.5	1.714	3.80

The length of the forearm, which can be easily and accurately taken from a specimen, shows a low coefficient of variation, and thus is a good indication of size in this species of bat.

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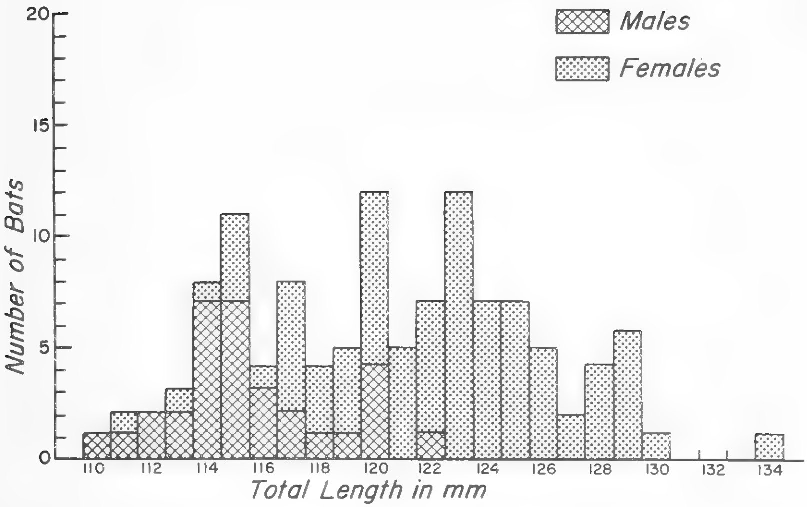

Figure 1. Variation in total length of *Eptesicus fuscus*

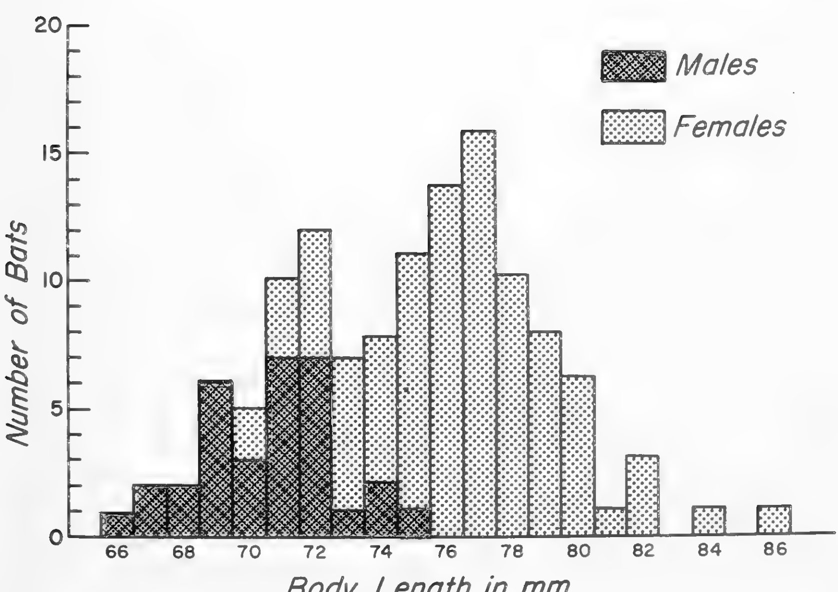

Figure 2. Variation in body length of *Eptesicus fuscus*

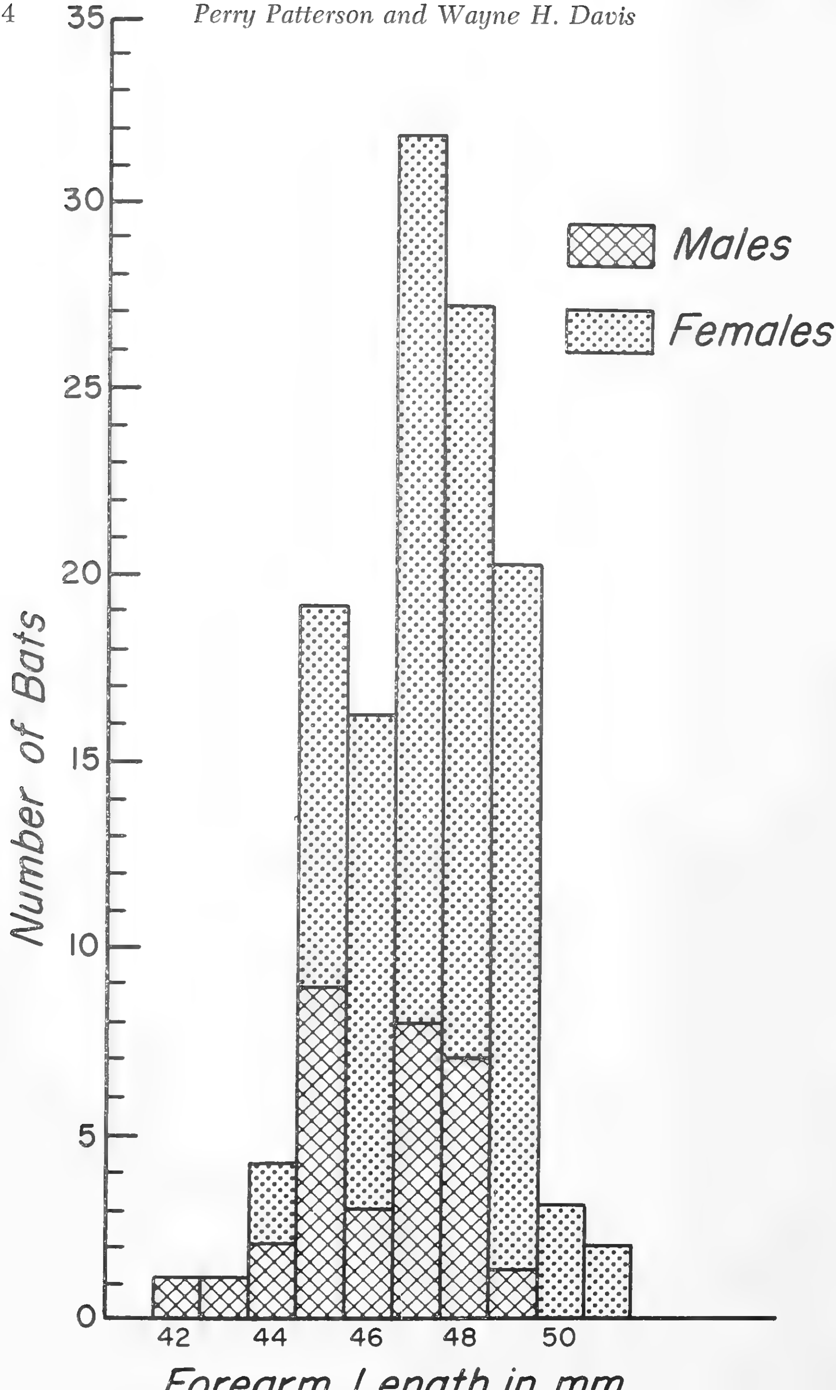

Figure 3. Variation in length of forearm in *Eptesicus fuscus*.

THE WALLTOWN, KENTUCKY METEORITE

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In 1963, free-lance geologist J. W. Flanigan of Waynesburg, Kentucky brought to our laboratories an angular rock fragment which he suspected to be a meteorite. Mr. Flanigan reported that the specimen was one of several found originally in 1956 and 1957 on a farm owned by Henry Naper near Walltown, Casey County, Kentucky (37°19′30″ N. Latitude, 84°43′0″ W. Longitude). The specimen was found on strata described by Mr. Flanigan as Upper Mississippian. He indicated that other fragments had been discarded with rubble used to fill a large sink hole on the farm. The original mass of material may have been as much as ten times the 1.6 kilogram mass of the fragment retained.

Inspection in this laboratory confirmed that this specimen was a badly weathered fragment of an ordinary chondrite. The specimen exhibited no fusion crust and both exterior and interior were dark reddish-brown in color. Freshly fractured surfaces exhibited extremely small flecks of free metal phase and indistinct chondrule inclusions. The specimen has a distinct dreikanter-like shape (Figures 1 and 2).

Three 350 milligram interior samples of the meteorite were analyzed for major elements using a scheme similar to that described by Easton and Lovering (1963). An exception to this scheme was that silicon was determined by nondestructive fast neutron activation analysis acording to the method of Vogt and Ehmann (1965). The averages of these three replicate analyses are given in Table I. The results of the analyses are consistent with the classification of the meteorite as a low-iron (L-group) ordinary chondrite. This group of meteorites is characterized by having a large part of their iron in ferromagnesian silicates. Their FeO contents range from 12 to 22% and their average total iron content is 22.33% (Mason, 1962). The total iron content of the Walltown meteorite is 23.7%.

The Walltown meteorite is the 19th meteorite find recorded for the State of Kentucky. There have also been four observed meteorite falls collected in Kentucky (Hey, 1966). The badly weathered condition of this meteorite would appear to preclude its widespread use in studies of meteorite composition. Fragments of the specimen are currently in the private collection of W. D. Ehmann and the main mass is in the possession of Mr. Flanigan.

Acknowledgements

The assistance of Mr. J. W. Flanigan in bringing this specimen to our attention and permitting its use in the scientific studies is greatly appreciated. This work was supported in part by the U.S. Atomic Energy Commission, Contract No. AT–(40-1)–2670.

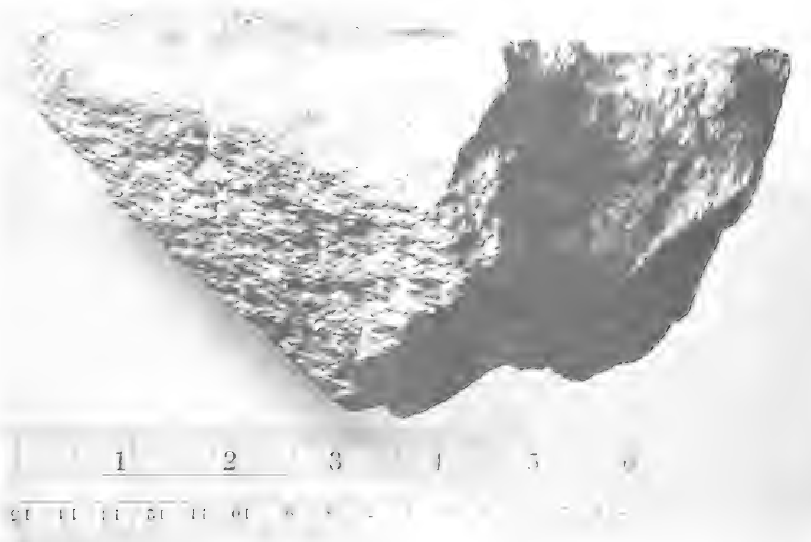

Figure 1.—Side view of the Walltown meteorite illustrating dreikanter-like shape.

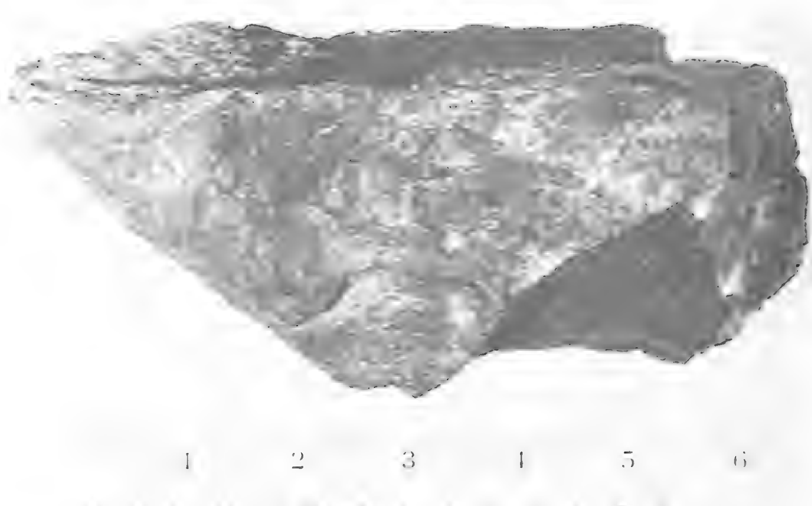

Figure 2.—Walltown meteorite rotated to show fresh fractures.

Table 1. Major Element Analysis of the Walltown, Kentucky Chondrite

	% of phase	% of whole meteorite	Average Composition of L-Group Chondrites*
Metal Phase			
Fe	80.7	7.0	7.04
Ni	16.2	1.4	1.06
Co	3.1	0.3	0.07
	100.0	8.7	8.17
Sulfide Phase			
FeS	100.0	5.3	5.77
Silicate Phase			
SiO_2	46.2	39.6	39.49
MgO	24.0	20.6	24.55
$FeO^{\dagger}$	20.0	17.1	14.97
Al_2O_3	4.8	4.1	2.61
CaO	2.3	2.0	1.96
Na_2O	1.4	1.2	1.04
K_2O	0.46	0.40	0.18
Cr_2O_3	0.15	0.11	0.43
MnO	0.43	0.37	0.27
TiO_2	0.11	0.09	0.11
C	0.11	0.09	-----
P_2O_5	trace	trace	0.24
$+H_2O$, $-H_2O$	n. d.	n. d.	-----
	100.0	85.7	85.85
Whole Meteorite		99.7	99.79
Total Iron		23.7	22.33

* As given by Mason (1962).

† All oxidized iron reported as FeO

n. d. = Not determined.

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FOREARM LENGTH AND WINGSPREAD OF *MYOTIS SODALIS*

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On December 2, 1967 the right forearm of 378 male and 425 female and the wingspread of 63 male and 61 female *Myotis sodalis* were measured. The bats were collected in Bat Cave, Carter Caves State Park, and were released unharmed. The forearm was measured to the nearest 0.1 millimeter with dial calipers, and the wingspread to the nearest millimeter along a meter stick. The results are plotted in Figures 1 and 2. No sexual dimorphism in wing dimensions is readily apparent in these measurements.

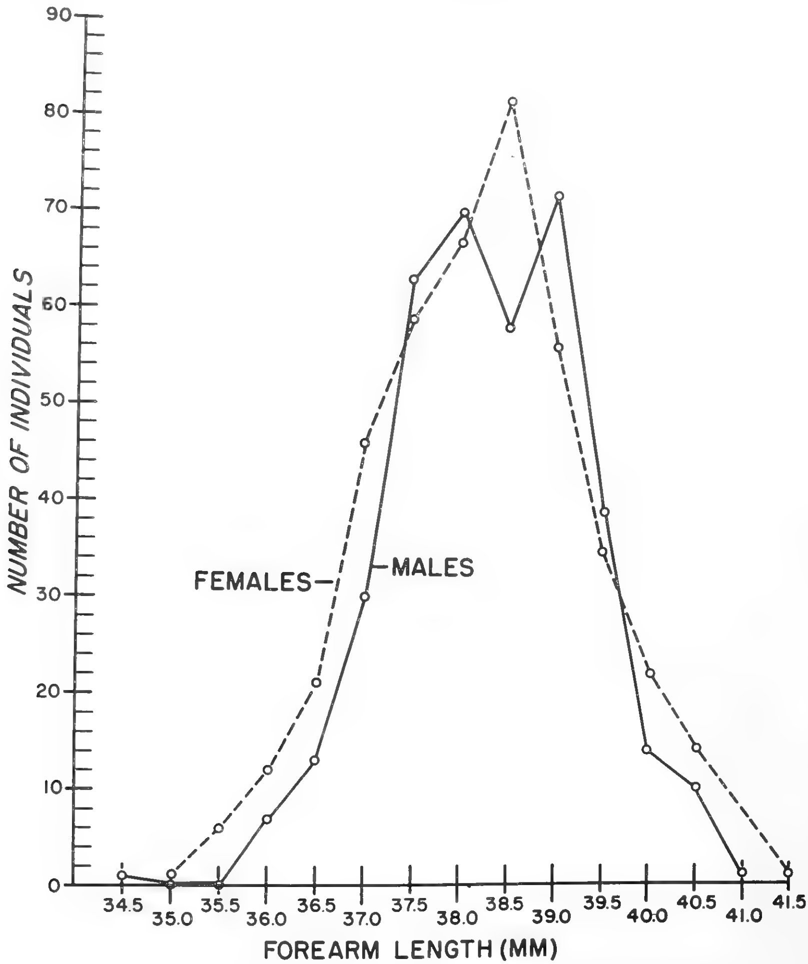

Figure 1.—Individual variation in the forearm length of *Myotis sodalis*.

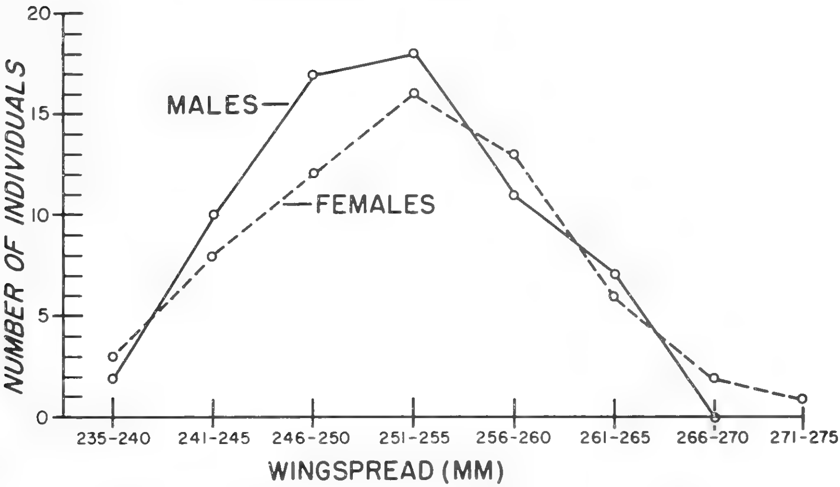

Figure 2.—Individual variation in the wingspread of *Myotis sodalis*.

MARGINAL RECORD OF *PARASCALOPS BREWERI* (BACHMAN) FROM KENTUCKY

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On March 9, 1967, a female *Parascalops breweri* (Bachman), the hairy-tailed mole, was found dead along with a *Blarina brevicauda carolinensis* (Bachman) at the entrance to a large den hole. The collection site was ½ mi. S W of Morrill (Jackson Co.) in the Knobs region of Rockcastle County, Kentucky. Hall and Kelson, The Mammals of North America, p. 71, 1959, list "Triplet Creek near Clearfield (Welter and Sollberger, 1939:78)" as the western marginal record for Kentucky; however, the specimen described herein was found 44 miles south and 43 miles west of this record. Damage which had occurred to the specimen prevented any accurate measurements from being made. The specimen is preserved in formalin in the collection of the senior author.

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VEGETATION OF THE PLEISTOCENE DRIFT REGION, NORTHERN KENTUCKY*

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INTRODUCTION

Vegetation associated with glacial deposits has been shown by Braun (1951) to be floristically distinctive, but ecological relationships of this association have been inadequately explored. This investigation was undertaken in order to determine the effects of glacial deposits on the composition and structure of vegetation that currently is growing on such deposits.

The area that was studied is in the northwestern part of Boone County, Kentucky, in the northern part of the Bluegrass region. The city of Cincinnati, Ohio, is located immediately to the east across the Ohio River. The report area is that part of Kentucky in which the thickest and most extensive glacial deposits accumulated during Pleistocene time. These deposits have been studied by Leverett (1929) and by Ray (1966). Research on the vegetation of these deposits was restricted, for this investigation, to woody plants because they were expected to most effectively reflect plant community dynamics.

This report is based on a thesis submitted as part of the requirements for the Master of Science degree at the University of Kentucky. I appreciate the generous help of E. T. Browne, Jr., now of the Memphis State University, and of John Warden of East Tennessee State University. L. L. Ray, H. T. Shacklette, and Frank Whitmore, all of the U.S. Geological Survey, provided guidance in the field and assistance with the manuscript.

DESCRIPTION OF THE AREA

Climate

The mean daily temperature of Boone County, 54.2°F., denotes a mild climate for the area. The mean annual rainfall for Boone County is 37 inches; that for the State as a whole is about 45 inches. Winds in the vicinity of Boone County tend to be higher than the State average (U.S. Department of Commerce, 1957). Because of the Ohio River, the northern and western parts of the county are more moist than the uplands in the eastern and southern parts.

Geology and Physiography

The bedrock of Boone County is primarily Ordovician limestone and shale of Eden, Maysville, and Richmond age (McFarlan, 1943). Of the three, rocks of Maysville age, chiefly limestone, occur most commonly in outcrops throughout the county.

* Publication authorized by Director, U.S. Geological Survey.

In addition to the bedrock, unconsolidated Pleistocene glacial deposits, which vary greatly in composition and thickness, mantle the northwestern part of Boone County. The approximate glacial border has been mapped by Ray (1966). Residual soils are also a part of the surficial materials and are well developed on the glacial deposits and on bedrock where glacial deposits are absent.

The oldest glacial deposit is deeply weathered till of Nebraskan age. A younger till, also highly weathered, has been assigned a Kansan age. These deposits, which are as much as 20 feet thick, are commonly so greatly weathered that they are difficult to recognize as distinct and separate strata. They are, therefore, considered to be one unit and are referred to collectively as "till." Drift from the Illinoian Glaciation occurs only sporadically in the area and is confined to the valley of the Ohio River (Leighton and Ray, 1966). Although glacial ice did not extend into Kentucky during the Wisconsin Glaciation of the Pleistocene, a well-leached layer of loess, of Wisconsin age and 2-3 feet thick, commonly caps the till deposits (Flint, 1957). Both till and loess are highly eroded and commonly are completely absent, especially from stream valleys. Glacial erratics, weighing as much as 16 tons, have been found in Boone and other counties in northern Kentucky, both within and beyond the glacial boundary (Leverett, 1929).

Although exposures of the substrate under the vegetation sample sites were not available in many places, the nature of the substrate could usually be determined by means of a soil auger. An additional means of distinguishing till areas from non-till areas was by recognition of undulations in contour lines on topographic maps (L. L. Ray, oral commun., 1965); the undulations reflect the weathering pattern of the till.

The area of study is one of moderate relief with flat uplands 800-900 feet in altitude in the eastern and southern parts. The western and northern parts are more highly dissected because of the erosional activity of the Ohio River and its tributaries. The valley bottom of the Ohio River lies some 300 feet below the uplands, the river itself having a normal pool level of 455 feet above sea level. Erosion has effectively removed whatever surface features were originally formed by glaciation during the Pleistocene Epoch so that, at present, almost no physiographic evidence of glaciation exists in the area.

Soils

Because of the variety of parent materials present and variation in physiography, soils in the study area are of many different series. Parent materials include limestone and shale bedrock, alluvium, colluvium, deep to shallow loess, and till. Most of the soils examined in this study were thick, ranging from 2 to 6 feet. The lower annual precipitation rate may have contributed to lesser erosion and deeper soils than in most areas of the State. The Bluegrass region, as a whole, has deeper soils than occur in other parts of the State (McFarlan, 1943). No attempt was made in this investigation to correlate soils of the study sites with formal soil series; information on soil series of the area has been given by Windsor and Bailey (1964). Silt loam soils predominate in the study area and soil drainage generally is good. A few areas of the uplands, however, where till is the substrate, appear to be poorly drained. More specific soil characteristics are given with the descriptions of individual sample sites. The soils under well-forested sites have a dark and thick A_1 layer in the profile. These dark soils are the melanized soils of the deciduous forests that are referred to by Braun (1950).

VEGETATION STUDIES

Regional Flora

This study of vegetation was restricted to the woody plants of the area, because these species are considered to be more responsive to physical environment than are the herbaceous plants. The latter exhibit more response to the biotic factors in the environment and therefore tend to vary more in presence and abundance over a given period of time than do the more extensively rooted woody plants.

An investigation of the Boone County flora that was made in the late 1800's (Nelson, 1918) lists 26 families, 43 genera, and 66 species of woody plants. The extent of the Nelson collection in time and in geographic area within the county is not known.

A collection made during this study includes 52 species, which represent 42 genera and 26 families. Voucher specimens have been deposited in the University of Kentucky Herbarium. Taxonomic nomenclature follows that of Gleason and Cronquist (1963). No species observed in this work was judged, because of its presence, to be of unusual distribution, nor were there noticeable absences of species that are found elsewhere in the Bluegrass region.

Ecological Methods

Whereas presence of a certain group of species is considered to be the most important factor in floristic studies, the relative abundance of those species and the role of dominants are more important in ecological studies. In order to study quantitative relationships of the species observed, thirteen forest sample sites were selected in the study area. An effort was made to choose sites that had a variety of directions of exposure and degrees of slope. Insofar as was possible, stands of timber were chosen which seemed to represent old-growth woods. However, because of excessive disturbance by cultivation, logging, grazing, and urbanization, desirable sample sites were difficult to obtain. With one possible exception, no forests were observed which might approximate so-called virgin stands.

The Bitterlich sampling method was used because of its efficiency and accuracy (Grosenbaugh, 1952). This is a transect method which measures forest basal area, *i.e.*, the cross-sectional area in units, such as square feet of trees per acre, with the diameters of the trees measured at 4.5 feet above the ground. In this study the amount of basal area has been used as an indicator of the degree of stand maturity. A high basal area denotes an old-growth stand. Basal area data are given with the descriptions of sample sites. No trees of less than 4 inches in diameter were included in the samples. The percentage values given in Table 1 were derived from data that were collected in the sampling of basal areas.

Description of Sample Sites

The thirteen sample sites are described as to location, general vegetational information, soil data, slope, date sampled, and total basal area as follows:

I. Southwestern Boone County, Rising Sun quadrangle, approximately 1 mile southwest of Big Bone Lick, 38° 53′ 15″ N., 84° 46′ 30″ W., dense woods with many large old trees; soil a black silty loam with A_1 3 inches thick, on loess and till; gentle slope to east; October 10, 1965; basal area 88 sq ft per acre.

II. Southwestern Boone County, Rising Sun quadrangle, approximately 1.5 miles southwest of Big Bone Lick, 38° 53′ 15″ N., 84° 46′ 50″ W.; old, open woods with many large trees; soil developed on river terraces, thin A_1, nuch outcrop and float of limestone; steep slope to west; October 10, 1965; basal area 102 sq ft per acre.

III. South-central Boone County, Rising Sun quadrangle, on Gunpowder Creek near end of Pope Road, 38° 57′ 20″ N., 84° 45′ 40″ W.; moderately dense woods with many old trees, numerous large dead honey locust trees; soil with black loamy A_1 as much as 3 inches thick; steep slope to southeast; October 31, 1965; basal area 117 sq ft per acre.

IV. South-central Boone County, Rising Sun quadrangle, along Riddles Run Road, half a mile from junction with Kentucky Highway 338, 38° 54′ 45″ N., 84° 48′ 00″ W.; woods with large trees and dense undergrowth; soil with black silty A_1 as much as 2 inches thick; moderate slope to northwest; October 31, 1965; basal area 80 sq ft per acre.

V. North-central Boone County, Lawrenceburg quadringle, sn slopes above Garrison Creek, 39° 54′ 45″ N., 84° 48′ 00″ W.; woods with large trees dense undergrowth; soil with black silty A_1 as much as 2 inches thick; moderate slope to northwest; October 31, 1965; basa larea 80 sq fet ped acre.

VI. North-central Boone County, Lawrenceburg quadrangle, along south bank of Ohio River near Barnard Cemetery, 39° 06′ 20″ N., 84° 48′ 50″ W.; dense woods on alluvial terraces, abundant *Asarum candadense* L., *Hydrangea arborescens* L., *Staphylea trifolia* L.; soil with 3-inch A_1, silty with increasing yellow clay downward; much limestone float; moderate slope to north; November 7, 1965; basal area 118 sq ft per acre.

VII. North-Central Boone County, Lawrenceburg quadrangle, 1 mile upstream on Ohio River from site VI., 39° 06′ 30″ N., 84° 47′ 55″ W.; similar in vegetational, edaphic, and slope factors to site VI., November 7, 1965; basal area 128 sq ft per acre.

VIII. Northwestern Boone County, Lawrenceburg quadrangle, on hillside above south bank of Woolper Creek, 1 mile east of Kentucky Highway 20, 39° 01′ 55″ N., 84° 49′ 45″ W.; open woods at edge of old road; soil with A_1 to 4 inches thick, black, silty with crumb structure; compact yellow clay at 8 inches in the profile; steep slope to north; November 16, 1965; basal area 109 sq ft per acre.

IX. Slightly south of and parallel to site VIII., but higher on hillside above Woolper Creek; open old woods with many large trees; A_1 of soil to 6 inches thick, silty and black; extremely steep slope to north; November 16, 1965; basal area 109 sq ft per acre.

X. Northwestern Boone County, Lawrenceburg quadrangle, on hillside above north bank of Woolper Creek, approximately 1.5 miles north of Kentucky Highway 18, 39° 02′ 10″ N., 84° 46′ 30″ W.; young thin woods with recent disturbance, as evidenced by presence of tree-of-heaven; soil with A_1 less than 1 inch thick, with underlying yellow clay; moderate slope to south; November 16, 1965; basal area 95 sq ft per acre.

XI. North-central Boone County, Burlington quadrangle, approximately 1 mile north of junction of Kentucky Highway 18 and 237, on land of oil company, 39° 02′ 0″ N., 84° 41′ 30″ W.; open old woods with few young trees, little ground cover; beech, though abundant as canopy tree, reproducing poorly; abundant *Epifagus virginiana* (L.) Bart.; black and silty soil with A_1 as much as 3 inches thick, compact yellow clay at 18 inches in the profile, till substrate; very slight slope; December 5, 1965; basal area 103 sq ft per acre.

XII. Northwestern Boone County, Lawrenceburg quadrangle, on south bank of Ohio River, 1.5 miles upstream from Petersburg, 39° 05′ 20" N., 84° 50′ 30″ W.; old woods; soil on alluvial terrace with A_1 as much as 4 inches thick, black loam with moderate clay content, yellow clay at 8 inches in the profile; moderate slope to north; December 5, 1965; basal area 103 sq ft per acre.

XIII. Northwestern Boone County, Lawrenceburg quadrangle, approximately half a mile southwest of Kentucky Highway 20, half a mile south-southwest of Petersburg, 39° 03′ 30″ N., 84° 52′ 12″ W.; dense stand of young trees and evidence of recent disturbance, several dead American elms ranging from 3 to 4 feet in diameter; soil with A_1 as much as 2 inches thick, on alluvial terraces; gentle slope to northwest; December 5, 1965; basal area 67 sq ft per acre.

Quantitative Data

Quantitative data are presented in Table 1. The sampling method that was used is primarily applicable to large trees; therefore, quantitative information on small trees and shrubs is not given. The woody understory of most sample sites consists primarily of *Cercis canadensis* L., *Acer Negundo* L., *Crataegus* spp., *Ostrya virginiana* (Mill.) K. Koch, *Sassafras albidum* (Nutt.) *Nees.*, *Cornus florida* L., *Carpinus caroliniana* Walt., *Asimina triloba* (L.) Dunal., and *Lindera Benzoin* (L.) *Blume.*

DISCUSSION

Features of Selected Communities

In comparing the forest communities of an east-facing slope with those of a west-facing slope, sites I and II, respectively, may be taken as examples. Site II has undergone more recent disturbance than site I, as indicated by the higher percentage of hackberry. The more mesophytic condition of east-facing slopes and less recent cutting are reflected in the relative abundance of both black cherry and shagbark hickory at site I. The percentages of the codominants, white ash and sugar maple, are not greatly different in the two communities, but the high percentage of each species at both sites is indicative of relatively old forest stands in this area.

In sites VII and X the degree of slope, substrate, and soil are similar. The principal environmental differences are the proximity to a stream and the degree of disturbance. The more mesophytic condition of site VII, caused by its north-facing slope and location near the Ohio River, is reflected in the high percentage of sugar maple (25 percent) at the site. On the south-facing slope at site X the relative abundance of sugar maple is only 9 percent whereas white ash remains at the same level, 31 percent, as at site VII. Although more recent cutting of sugar maple at site X may account for some of the difference in the abundance, much of the difference may be attributed to the different directions of slope at the two sites and the resulting moisture differences.

If sparseness of the codominants sugar maple and white ash is used as a criterion for the degree of disturbance, site V is a highly disturbed area. Site V has a southward slope, but does not differ markedly from the other sites in any other factors, except truncation of the A soil horizon. The truncation is due to erosion after logging and the subsequent changes in herbaceous vegetation. Sugar maple and white ash each constitute 3 percent of the total sample at site V, whereas the averages for all 13 sites are 22 percent ash and 20 percent maple. The most abundant species at this site are hackberry, yellow oak, black locust, and black walnut; the presence of the latter two indicate that a recent old-field succession has occurred in the development of this stand.

Site XI is the only truly upland community of the entire sample series. The black silty horizon of the soil appears to have been derived from loess; and a compact yellow clay, apparently the upper part of the underlying till, occurs at a depth of 18 inches in the profile. Because of the nature of the substrate and the lack of appreciable slope, this habitat is more poorly drained than the other sample sites. The more hydric condition is reflected in the vegetation: 48 percent sugar maple, the highest of all stands measured; 24 percent white ash, 4 percent black cherry, and 12 percent beech. The abundance of beech is noteworthy. Observations of other stands on the uplands which contain beech and the frequency of isolated individual beech trees in locations of the same type lead to the speculation that the original postglacial upland forests of Boone County may have been similar

Table 1. Percentage composition of canopy trees in thirteen forest sample sites, Boone County, Kentucky

[Species listed in approximate order of decreasing abundance. Percentages rounded to nearest whole number. A plus indicates presence of a species, but less than 1 percent. A minus indicates the absence of a species.]

Common and scientific names	Sites												
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
White ash (*Fraxinus americana* L.)	32	26	13	30	3	20	31	25	11	31	24	17	21
Sugar maple (*Acer saccharum* Marsh.)	22	33	15	11	3	27	25	5	27	9	48	28	4
Hackberry (*Celtis occidentalis* L.)	1	9	11	4	22	5	5	5	15	6	14	22	3
American elm (*Ulmus americana* L.)	1	4	1	3	5	7	7	6	4	8	-	6	1
Shumard's oak (*Quercus Shumardii* Buckl.)	5	3	1	+	9	1	1	-	3	1	5	1	3
Blue ash (*Fraxinus quadrangulata* Michx.)	+	+	12	2	+	10	10	-	10	17	-	6	3
Yellow oak (*Quercus prinoides* Willd.)	+	8	23	11	12	1	1	1	4	4	-	1	+
Black locust (*Robinia pseudoacacia* L.)	-	1	1	3	14	4	1	12	+	1	1	-	3
Black walnut (*Juglans nigra* L.)	2	2	-	3	17	2	1	2	-	4	1	-	-
Buckeye (*Aesculus glabra* Willd.)	-	1	-	-	-	5	2	1	1	3	-	5	15
Red elm (*Ulmus rubra* Muhl.)	-	3	-	1	1	3	4	5	10	-	-	1	4
Bur oak (*Quercus macrocarpa* Michx.)	2	2	1	4	4	1	-	12	1	-	-	1	1
Honey locust													

(Platanus occidentalis L.)	-	3	-	2	1	3	2	-	-	+	-	-	+
Basswood (Tilia americana L.)	-	-	2	-	-	5	2	-	13	1	-	1	-
Red cedar (Juniperus virginiana L.)	-	-	+	+	-	+	-	-	-	+	1	-	-
Bitternut hickory (Carya cordiformis (Wang.) K. Koch)	-	-	2	3	2	-	-	-	4	2	-	-	3
Black cherry (Prunus serotina Ehrh.)	6	-	1	-	-	-	-	3	1	+	4	-	-
Cork elm (Ulmus Thomasi Sarg.)	-	-	-	-	3	4	2	+	-	-	-	4	20
Shagbark hickory (Carya ovata (Mill.) K. Koch)	17	-	1	4	-	-	-	-	1	-	-	-	-
Red oak (Quercus borealis Michx. f.)	+	-	6	4	+	-	-	-	1	4	-	-	-
Osage orange (Maclura pomifera (Raf.) Schneid.)	-	-	-	+	-	-	-	+	-	-	-	-	7
Tree-of-heaven (Ailanthus altissima (Mill.)Swingle)	-	-	-	-	3	-	-	-	+	-	-	-	-
White oak (Quercus alba L.)	-	-	-	-	-	-	-	-	-	-	2	-	-
Beech (Fagus grandifolia Ehrh.)	-	-	-	-	-	-	-	-	-	-	12	-	-
Shingle oak (Quercus imbricaria Michx.)	1	-	-	-	-	-	-	-	-	-	-	-	-
Mulberry (Morus rubra L.)	1	-	1	2	-	-	-	-	-	-	-	-	-
Coffee tree (Gymnocladus dioica (L.) K. Koch)	-	-	-	-	-	-	-	-	-	-	-	-	+

Table 1. Percentage composition of canopy trees in thirteen forest sample sites, Boone County, Kentucky

[Species listed in approximate order of decreasing abundance. Percentages rounded to nearest whole number. A plus indicates presence of a species, but less than 1 percent. A minus indicates the absence of a species.]

Common and scientific names	Sites I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
White ash (*Fraxinus americana* L.)	32	26	13	30	3	20	31	25	11	31	24	17	21
Sugar maple (*Acer saccharum* Marsh.)	22	33	15	11	3	27	25	5	27	9	48	28	4
Hackberry (*Celtis occidentalis* L.)	1	9	11	4	22	5	5	5	15	6	14	22	3
American elm (*Ulmus americana* L.)	1	4	1	3	5	7	7	6	4	8	-	6	1
Shumard's oak (*Quercus Shumardii* Buckl.)	5	3	1	+	9	1	1	-	3	1	5	1	3
Blue ash (*Fraxinus quadrangulata* Michx.)	+	+	12	2	+	10	10	-	10	17	-	6	3
Yellow oak (*Quercus prinoides* Willd.)	+	8	23	11	12	1	1	1	4	4	-	1	+
Black locust (*Robinia pseudoacacia* L.)	-	1	1	3	14	4	1	12	+	1	1	-	3
Black walnut (*Juglans nigra* L.)	2	2	-	3	17	2	1	2	-	4	1	-	-
Buckeye (*Aesculus glabra* Willd.)	-	1	-	-	-	5	2	1	1	3	-	5	15
Red elm (*Ulmus rubra* Muhl.)	-	3	-	1	1	3	4	5	10	-	-	1	4
Bur oak (*Quercus macrocarpa* Michx.)	2	2	1	4	4	1	-	12	1	-	-	1	1
Honey locust (*Gleditsia triacanthos* L.)	+	3	8	1	4	-	-	11	-	1	-	-	11
Sycamore (*Platanus occidentalis* L.)	-	3	-	2	1	3	2	-	-	+	-	-	+
Basswood (*Tilia americana* L.)	-	-	2	-	-	5	2	-	13	1	-	1	-
Red cedar (*Juniperus virginiana* L.)	-	-	+	+	-	+	-	-	-	+	1	-	-
Bitternut hickory (*Carya cordiformis* (Wang.) K. Koch)	-	-	2	3	2	-	-	-	4	2	-	-	3
Black cherry (*Prunus serotina* Ehrh.)	6	-	1	-	-	-	-	3	1	+	4	-	-
Cork elm (*Ulmus Thomasi* Sarg.)	-	-	-	-	3	4	2	+	-	-	-	4	20
Shagbark hickory (*Carya ovata* (Mill.) K. Koch)	17	-	1	4	-	-	-	-	1	-	-	-	-
Red oak (*Quercus borealis* Michx. f.)	+	-	6	4	+	-	-	-	1	4	-	-	-
Osage orange (*Maclura pomifera* (Raf.) Schneid.)	-	-	-	+	-	-	-	+	-	-	-	-	7
Tree-of-heaven (*Ailanthus altissima* (Mill.) Swingle)	-	-	-	-	3	-	-	-	+	-	-	-	-
White oak (*Quercus alba* L.)	-	-	-	-	-	-	-	-	-	-	2	-	-
Beech (*Fagus grandifolia* Ehrh.)	-	-	-	-	-	-	-	-	-	-	12	-	-
Shingle oak (*Quercus imbricaria* Michx.)	1	-	-	-	-	-	-	-	-	-	-	-	-
Mulberry (*Morus rubra* L.)	1	-	1	2	-	-	-	-	-	-	-	-	-
Coffee tree (*Gymnocladus dioica* (L.) K. Koch)	-	-	-	-	-	-	-	-	-	-	-	-	+

to the present stand at site XI. Other areas of abundant beech have been observed in the northern part of the Bluegrass region by Braun (1950), although beech is not commonly found in the region as a whole.

Old beech trees in the study area have developed buttresses at the base of the trunk. These structures may indicate restriction of root growth caused by the imperviousness of till, and subsequent accumulation in the buttresses of carbohydrates which normally would be stored in roots (John Warden, oral commun., 1965).

Discussion of Selected Species

Some species are ecologically sensitive and therefore are restricted in range, but many species have great environmental tolerance. Climax species usually belong to the latter category; apparently such is the case with sugar maple and white ash, the dominant species observed in this investigation. However, community dominance is attained by those two species only when conditions approach the optimum.

White oak, a species which formerly was much more abundant in the Boone County area (Braun, 1950), has now been cut out to a very low abundance.

Tulip popular, a tree with wide ecological tolerance and one which is very abundant in most parts of Kentucky, is scarce in the area studied. Although it is reproducing well in a few areas of the county, it is not present in any of the sample stands. Such an anomaly may be attributed to severe cutting of this species. Early reports (Braun, 1950) point to a much greater abundance of the tree in this area.

One species, shingle oak, is scattered widely over the area of study, occurring most commonly along streams. On the Tazewell age terrace at Big Bone Lick it forms a nearly pure stand (Schultz and others, 1963). Its habitats in this area are similar to those of its usual location in glaciated poorly drained areas and on flood plains. The abundance of this species is not accurately indicated by data in Table 1 because no sample sites were located adjoining streams.

SUMMARY AND CONCLUSIONS

The recording of vegetational history and the prediction of future ecological developments are difficult in areas which have been extensively modified by activities of man. However, certain plant communities in some areas may serve to indicate change and development of past community structure. These plant assemblages also may suggest the types of potential natural communities that could develop if no further disturbance occurred. In the glaciated part of Boone County, Kentucky, white ash and sugar maple are the characteristic codominant forest species. These are followed in abundance by American elm and hackberry. The dominance of the first two species indicates that, in spite of the extensive disturbance of the area, strong tendencies in succession exist toward the development a physiographic climax forest. As viewed on a regional basis, present succession appears to be toward the development of forests of mixed composition, but these forests are divisible into discrete units that are characterized by species with similar environmental requirements. Furthermore, it is postulated that this type of forest occupied these sites before human activity produced the present disclimax conditions.

A melanized soil occurs in the A horizon at many of the sites. Because the formation of such a soil from a mull humus is a slow process, its presence indicates that a moist deciduous forest of long duration formerly occupied the site. For melanization to have occurred, the trees of the forest must have been those which yielded basic forest litter. Wilde, Wilson, and White (1949) stated, ". . . . the prerequisites for the development of mull soils include an abundant supply of bases, a favorable position of the ground water table, or forest cover of soil-conserving hardwoods such as hard maple, beech, basswood, and white ash." Both ash and maple occupy the sites having this relict soil type. If the sites had originally been more xeric, oaks, conifers, and other trees that produce an acid litter would have dominated, and podzolization rather than melanization would have occurred. This condition would now be evident as a weak podzolized layer in the lower part of the A soil horizon.

The presence of hackberry and American elm indicates the disclimax nature of the present stands. These species are early invaders of the deforested site and, where soil moisture is adequate, they will be replaced initially by maple and ash and eventually by some degree of codominance of beech and maple. Such succession occurs because the seedlings of maple and beech can develop in the shade of all other trees in the region, whereas the seedlings of the other tree species cannot grow under a closed canopy of beech and maple.

The abundance of maple and the scarcity of beech at sites where both could grow equally well may be attributed to the more efficient seed dispersal of maple. Thus, it may be concluded that there has been insufficient time since the last deforestation for beech to have made significant colonization of the sites. The forest pattern of codominant beech and maple stands commonly reflects slight differences in water content and aeration of soils. Both species require abundant moisture, but maple requires a greater degree of soil aeration.

A common property of old glacial deposits that are extensively weathered is the concentration of clay-sized particles that can impede the free percolation of soil water. Such a condition of soil moisture favors the development of beech and maple stands at sites which would otherwise be too xeric for these species. It is, therefore, postulated that moist, mesophytic forests were once more prevalent on the glacial till in northern Kentucky than the relief would suggest and that, if these areas were left undisturbed, this forest type would again predominate.

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KIDNEY EFFICIENCIES OF THREE PENNSYLVANIA MICE

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Mammal kidneys are capable of concentrating urine and ridding the body of excess salts. This ability has been studied in a number of rodents. *Citellus leucurus* (Bartholomew and Hudson, 1959) and *Meriones unguiculatus* (Winkleman and Getz, 1962) are capable of surviving on 1.0 M salt solutions; and *Dipodemys merriami* (Schmidt-Nielsen, 1950), *Reithrodontomys megalotis* (MacMillen, 1964), *Reithrodontomys raviventris halicoetis* (Fisler, 1963; Haines, 1964), *Peromyscus maniculatus rubidus* (Fisler, 1962), and *Gerbillus gerbillus* (Burns, 1956) can use sea water (= .57 M NaCl). Mice with less efficient kidneys die at lower salt concentrations.

Ninety *Peromyscus leucopus noveboracensis,* 87 *Microtus p. pennsylvanicus,* and 71 *Mus m. musculus* living sympatricly were trapped alive in Lancaster County, Pennsylvania. The mice were brought to the laboratory and allowed to adjust to captive conditions. Each was kept in an individual cage provided with a water bottle and given distilled water ad libitum. The mice were provided with a standard diet of dry laboratory Purina rabbit chow. The room was maintained at 25°C and lighted for 10 hours daily. The relative humidity was uncontrolled and varied from 40 to 85%, thus giving a comparison over a wide range.

After they had adjusted to captivity, daily water consumption was measured over a five-day period. The mice were weighed at the beginning and end of this period. Daily water consumption is represented as a function of the mean body weight of each mouse over the five-day period (Table 1). The drinking water of each mouse was then replaced with a .10 molar NaCl solution for five days, then .20 M, .30 M, up to .60 M (sea water = .57 M NaCl) at five-day intervals, or until the animal died. Deaths were as-

Table 1. Distilled Water Consumption of Three Species of Pennsylvania Mice

Species	Number	Body Weight (± SD) (g)	Mean Water Consumption (± SD) (cc/day)	Mean Water Consumption in cc/body g/day
Peromyscus l. noveboracensis	90	19.9 ± 2.7	3.5 ± 0.3	0.12 ± 0.02
Microtus p. pennsylvanicus	87	29.1 ± 2.8	6.1 ± 0.3*	0.21 ± 0.02*
Mus m. musculus	71	11.0 ± 3.0	2.0 ± 0.4	0.17 ± 0.01

* Difference significant at 0.05 level as compared to the consumption of Mus and Peromyscus.

sumed to occur because an animal could no longer rid its body of the excess NaCl and developed a negative water balance as determined by loss of body weight. Tolerance of NaCl solutions is considered to represent the kidney efficiency of each mouse. The mean survival time in days and the range in length of survival were recorded. The mean per cents of body weight loss each mouse withstood before succumbing and lost per day were calculated (Table 2). Ten mice of each species were placed directly on a 1.0 M NaCl solution, and their mean period of survival calculated.

Table 2. Weight losses and Survival Times of Three Species of Pennsylvania Mice on Increasing Concentrations of Salt Water Ranging from 0.1 M to 0.6 M.

Species	No.	Mean days of survival (± SD)	Range in length of survival	Means % Wt. loss at death (± SD)	Mean Wt. loss/day (±SD) (g)	Range Wt. loss/day (g)
Peromyscus l. noveboracensis	80	18.2 ± 1.2*	17-20	25.9 ± 3.2	0.35 ± 0.13*	0.26-0.44
Microtus p. pennsylvanicus	77	12.7 ± 2.0*	9-16	25.3 ± 3.0	0.62 ± 0.10*	0.51-0.69
Mus m. musculus	61	14.6 ± 4.9*	7-28	21.2 ± 3.5	0.22 ± 0.14*	0.10-0.25

* Differences statistically significant at the 0.05 level.

The possibility that some non-metabolic water could be obtained from the dry feed provided was investigated. An amount of feed comparable to that eaten weekly was weighed, and then heated in an oven to drive off any available moisture. The feed was reweighed and the per cent of available water calculated.

The results shown in Table 2 give some indication of the adaptive ability of the kidneys to rid the body of excess NaCl in the water supply. This is an important adaptation for mammals living in areas where the plants and/or available drinking water have a high mineral content. The mice succumbed on NaCl solutions ranging from .20 to .60M. The mean length of survival varied from 12.7 days in *Microtus* to 18.2 days in *Peromyscus*. Brown (1964) in a study of Missouri mice found the average days of survival on increasing salt water concentrations to be 18.5 for *P. leucopus*, 19.6 for *P. boylii* and 17.9 for *P. maniculatus*.

Peromyscus withstood the greatest weight loss, while *Mus* withstood the least. *Microtus* withstood nearly as great a weight loss as *Peromyscus*, but dehydrated (e.g. lost weight more rapidly due to greater urine volume) and died sooner. The 50% lethal points (that NaCl concentration where 50% of the mice died) were recorded as follows for each mouse: .30 M for *Mus* and *Microtus* and .40 M. for *Peromyscus*. Getz (1966) also recorded .30 M as the 50% lethal point in his study of salt tolerances of salt marsh *Microtus pennsylvanicus*. Getz (1963) compared the kidney efficiencies of *M. pennsylvanicus* to *M. ochrogaster*. *Microtus ochrogaster* utilized a higher molarity of salt water. Only one *M. pennsylvanicus* survived a molarity above .25, while only one *M. ochrogaster* died below this. One *M. ochrogaster* lived over 30 days and reached .50 M before it died. Getz believed this indicated a greater kidney efficiency in *M. ochrogaster*. Getz (1966) also compared salt marsh and grassland *M. pennsylvanicus* by placing both on salt water, and found no significant differences in the ability of the two populations to utilize salt water.

When first introduced to the salt water, all three species increased their consumption of water and their weight increased as a result. As the concentrations were increased the amount consumed by *Peromyscus* and *Mus* gradually decreased, as did their weight. Only *Microtus* continued to drink at an increased rate, while losing weight rapidly, until they succumbed. Chew (1951) restricted the drinking water of *P.* 1. *noveboracensis* from Illinois and Michigan, and found that water conservation was effected by reduction of urine volume. During the present study, the *Peromyscus* and *Mus* urinated less often and the *Microtus* more frequently when placed on salt water. Chew (1951) found that some of his mice recovered from losing 32 to 45% of their initial weight. In this study, the weight loss at death in *P.* leucopus was 25.9%. Brown (1964) reported a 26.6% weight loss in *P. leucopus,* 20.2% for *P. boylii,* and 22.0% for *P. maniculatus.*

A single house mouse survived 28 days during the salinity test, but refused the water after 10 days (after .20 M). The dry feed contained 10.8% water. The mouse at death had lost 23.1% of its original weight. No other house mouse survived over 17 days on salt water. This is surprising since Haines and Schmidt-Nielsen (1967) demonstrated that *Mus* from a variety of habitats and geographic localities is independent of drinking water as long as relative humidity was greater than 60%, as it was during part of this study. It is possible their feed contained more water than that used in this study.

When placed on a 1.0 M solution, all mice were affected about equally. *Mus* had a mean survival period of 2.2 days (range 2-3 days), *Microtus* 2 days, and Peromyscus 1.8 days (range 1-2 days).

The results of this study indicate that *Peromyscus l. noveboracensis* has more efficient kidneys for concentrating and ridding the body of excess salts, while the kidneys of *Microtus p. pennsylvanicus* were the least efficient of the three mice studied. The results reported here as well as those of MacMillen (1964), Fisler (1962), Haines (1964), Brown (1964), Chew (1951), and Getz (1963, 1966) indicate that the members of the subfamily Cricetinae have more efficient kidneys than members of the subfamily Microtinae. Apparently *Mus m. musculus* falls somewhere between these two subfamilies.

I would like to thank Dr. Wayne H. Davis for critically reading this manuscript.

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A NEW SIZE RECORD FOR THE EASTERN COTTONWOOD?

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The American Forestry Association lists as the size record for the Eastern Cottonwood (*Populus deltoides Bartr.*), a specimen near Kearney, Nebraska. A recent discovery by the authors and subsequent measurements indicates that a larger tree exists in West Kentucky.

Based on the total points formula (circumference in inches plus height in feet plus one-quarter maximum spread in feet) the West Kentucky specimen may well exceed the established record.

The tree is located about five miles north of Hickman, Fulton County, Kentucky, near the mouth of Obion Creek. It measures 29 feet in circumference, has a maximum sperad of 125 feet and is 110 feet in height. These measurements have been forwarded to the American Forestry Association and a decision is pending regarding its record status.

THE FLORA OF MURPHEY'S POND[1]

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Most of western Kentucky including the Murphey's Pond area is included in the subregion of forests called Mississippi Embayment of the Western Mesophytic Forest Region. Extending from the Tennessee River on the east to the alluvial plains of the Mississippi River on the west, this area is a northern extension of the Gulf Coastal Plain. A belt of loess hills lines the western margin of the region. "The area displays a mosaic of unlike vegetation types, of prairie, oak-hickory forest, swamp forest, and mixed mesophytic communities. The broad alluvial valleys are occupied by phases of swamp forest extensions from those of Mississippi alluvial lands." (Braun, 1950).

Murphey's Pond, in Hickman County about 8 miles southwest of Fancy Farm, next to Kentucky Highway 307, is an example of the swamp forest and is the most unique remaining example of the cypress swamps which once were prevalent in western Kentucky. *Taxodium distichum,* the dominant tree, is typical of the swamp forests of Southeastern United States.

According to the United States Department of the Interior Geological Survey map of the Dublin quadrangle, Murphey's Pond and the surrounding area total about 1000 acres, while the actual open-water portion is about 25 acres. Obion Creek runs through the area for approximately 1.5 miles. It is believed that the swamp was formed by the same earthquakes which in 1811 formed Reelfoot Lake. For the greater portion of the actual pond, the water is little over 6 feet deep. Hummocks in the open water formed by the bases of the trees with surrounding vegetation are numerous. The smallest of these hummocks are approximately 3 feet in diameter, while larger hummocks or groups of hummocks may range to over 20 feet long. *Taxodium distichum, Rosa palustris, Cephalanthus occidentalis, Acer rubrum, Galium tinctorium,* and *Itea virginica* are the most common plants found on the hummocks. *Wolfiella floridana* and *Spirodela polyrhiza* are floating in the water between trees, and *Ceratophyllum demersum* is submerged in the water. The trees found in the swamp area are the cypress, ash, oak, maple, hickory, cottonwood, sweet gum, elm, willow, redbud, and birch. Around the swamp's edges are herbaceous plants such as *Iris virginica, Senecio aureus, Habenaria peramoena,* and various ferns.

Following is a list of plants collected from Murphey's Pond and filed in the Murray State University Herbarium. These plants were collected on nine

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[2] Based on a paper submitted by the senior author in partial fulfillment of the requirements for the Bachelor's degree at Murray State University.

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field trips. Two were made in the summer of 1965 and the rest were made in the spring and summer of 1967. There are 158 taxa of 130 genera in 69 families. Notable are those plants indicated by asterisks, which were not found in either McFarland's (1942) or Braun's (1943) lists of vascular plants of Kentucky. Neither were they cited from Kentucky in Gleason (1963) or Fernald (1950). The listing follows McFarland's (1942) format. When a new record occured Fernald (1950) was used for taxonomic reference.

THE FLORA OF MURPHEY'S POND

PTERIDOPHYTA

Family

1. Polypodiaceae
   Asplenium platyneuron (L.) Oakes
   Onoclea sensibilis L.
   Polystichum acrostichoides (Michx.) Schott
   Woodsia obtusa (Spreng.) Torr.
2. Selaginellaceae
   Selaginella apoda (L.) Fern.
3. Ophioglossaceae
   Botrychium virginianum (L.) Sw.
   * *Ophioglossum vulgatum* L.

SPERMATOPHYTA

4. Pinaceae
   Taxodium distichum (L.) L. C. Richard
5. Typhaceae
6. Sparganiaceae
   Sparganium androcladum (Engelm.) Morong
7. Gramineae
   Panicum sp.
8. Cyperaceae
   Carex lurida Wahlenb
   Carex stricta Lam.
   Scirpus cyperinus (L.) Kunth
   * *Scleria nitida* Willd.
9. Araceae
   Arisaema dractontium (L.) Schott
   Peltandra virginica (L.) Kunth
10. Lemnaceae
   Spirodela polyrhiza (L.) Schleid
   * *Wolffiella floridana* (J. D. Sm.) C. H. Thompson
11. Commelinaceae
   Commelina virginica L.
12. Juncaceae
   Juncus effusus var. *solutus* Fern.
   Luzula multiflora (Ehrh.) Lejeune
13. Liliaceae
   Allium canadense L.
   Smilax glauca Walt.
14. Iridaceae
   Iris virginica L. var. *Shrevei* (Small) Anderson
   Sisyrinchium albidum Raf.
15. Orchidaceae
   Habenaria flava (L.) Gray
   Habenaria peramoena Gray
   Liparis lilifolia (L.) Richard
   Tipularia discolor (Pursh) Nutt.
16. Saururaceae
   Saururus cernuus L.
17. Salicaceae
   Populus deltoides Marsh.
   Salix fragilis L.
   Salix nigra Marsh.
18. Juglandaceae
   Carya ovata (Mill.) K. Koch.
   Juglans nigra L.
19. Betulaceae
   Betula nigra L.
   Corylus americana Walt.
20. Fagaceae
   Quercus falcata Michx.
   Quercus lyrata Walt.
   Quercus palustris Muench.
   Quercus Phellos L.
   Quercus velutina Lam.
21. Ulmaceae
   Ulmus alata Michx.
   Ulumus americana L.
22. Urticaceae
   * *Pilea fontana* (Lunell) Rydb.

23. Polygonaceae
    Polygonum punctatum Ell.
    Rumex altissimus Wood.
24. Aizoaceae
    Mollugo verticillata L.
25. Caryophyllaceae
    Cerastium arvense L.
26. Ceratophyllaceae
    Ceratophyllum demersum L.
27. Ranunculaceae
    Clematis virginiana L.
    Ranunculus bulbosus L.
    Ranunculus carolinianus DC.
28. Magnoliaceae
    Liriodendron Tulipifera L.
29. Annonaceae
    Asimina triloba (L.) Dunal.
30. Berberidaceae
    Podophyllum peltatum L.
31. Lauraceae
    Sassafras albidum (Nutt.) Nees
32. Cruciferae
    Arabis virginica (L.) Poir.
32. Cruciferae
    Arabis virginica (L.) Poir.
    Cardamine bulbosa (Schreb.) BSP.
    Cardamine Douglassii (Torr.) Britt.
    Draba brachycarpa Nutt.
    Draba verna L.
33. Saxifragaceae
    Hydrangea arborescens L.
    Itea virginica L.
34. Hammamelidaceae
    Liquidambar Styraciflua L.
35. Rosaceae
    Geum canadense Jacq.
    Potentilla canadensis L.
    Prunus americana Marsh.
    Prunus Munsoniana Wight & Hedrick
    Rosa palustris Marsh.
    Rosa setigera Michx.
    * *Rubus pensilvanicus* Poir.
36. Leguminosae
    Amorpha fruticosa L.
    Apios tuberosa Muench.
    Cassia fasciculata Michx.
    Desmodium nudiflorum (L.) DC.
    Robinia Pseudo-Acacia L.
37. Geraniaceae
    Geranium carolinianum L.
38. Oxalidaceae
    Oxalis stricta L.
39. Anacardiaceae
    Rhus copallina L.
40. Aquifoliaceae
41. Celastraceae
    Celastrus scandens L.
    Euonymus americanus L.
42. Aceraceae
    Acer Negundo L.
    Acer rubrum L.
43. Balsaminaceae
    Impatiens biflora Walt.
44. Vitaceae
    Parthenocissus quinquefolia (L.) Planch.
    Vitis Labrusca L.
    Vitis palmata Vahl.
45. Hypericaceae
    Hypericum Drummondii (Grev. & Hook.) T. & G.
46. Violaceae
    Viola missouriensis Greene
    Viola Rafinesquii Greene
47. Passifloraceae
48. Melastomaceae
    Rhexia mariana L.
49. Onagraceae
    Ludwigia alternifolia L.
50. Umbelliferae
    Cicuta maculata L.
    Cryptotaenia canadensis (L.) DC.
    Daucus Carota L.
    * *Eryngium aquaticum* L.
    Sanicula gregaria Bickn.
51. Cornaceae
    Cornus florida L.
    Cornus racemosa Lam.
52. *Oleaceae*
    Fraxinus quadrangulata Michx.
    Fraxinus tomentosa Michx. f.
53. Gentianaceae
    Sabatia angularis (L.) Pursh.
54. Asclepiadaceae
    Asclepias perennis Walt.
55. Convolvulaceae
    * *Convolvulus arvensis* L.
56. Hydropyhllaceae
    Hydrolea uniflora Raf.
57. Boraginaceae
    Heliotropium indicum L.
    Myosotis verna Nutt.

58. Verbenaceae
Verbena hastata L.
59. Labiatae
Hedeoma pulegioides (L.) Pers.
Lamium amplexicaule L.
Lycopus virginicus L.
Prunella vulgaris L.
Prunella vulgaris L.
Pycnanthemum flexuosum (Walt.) BSP
Pycnanthemum pycnanthemoides (Leavenw.) Fern.
Salvia lyrata L.
Stachys tenuifolia Willd.
Teucrium canadense L.
60. Solanaceae
Solanum carolinense L.
61. Scrophulariaceae
Mimulus alatus Ait.
Penstemon alluviorum Pennell
Scrophularia marilandica L.
62. Bignoniaceae
Bignonia capreolata L.
Campsis radicans (L.) Seemann
Catalpa speciosa Warder
63. Acanthaceae
Ruellia sp.
64. Phrymaceae
Phryma Leptostachya L.
65. Plantaginaceae
Plantago aristata Michx.
66. Rubiaceae
Cephalanthus occidentalis L.
Galium circaezans Michx.
Galium pilosum Ait.
Galium tinctorium L.
Galium triflorum Michx.
* *Houstonia pusilla* Schoepf.
67. Caprifoliaceae
Lonicera japonica Thunb.
Sambucus canadensis L.
68. Campanulaceae
Specularia perfoliata (L.) A. DC.
69. Compositae
Ambrosia bidentata Michx.
* *Coreopsis oniscicarpa* Fern.
Erigeron pulchellus Michx.
Erigeron tenuis T. & G.
Eupatorium perfoliatum L.
Eupatorium serotinum Michx.
Helenium tenuifolium Nutt.
Krigia Dandelion (L.) Nutt.
* *Mikania scandens* (L.) Willd.
Pyrrhopappus carolinianus (Walt.) DC.
Rudbeckia hirta L.
Senecio aureus L.
Senecio glabellus Poir.
Vernonia altissima Nutt.
Vernonia missurica Raf.
Xanthium italicum Moretti

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CLUSTER OF NORMAL FAULTING IN THE NORTHWESTERN BLUEGRASS REGION OF KENTUCKY

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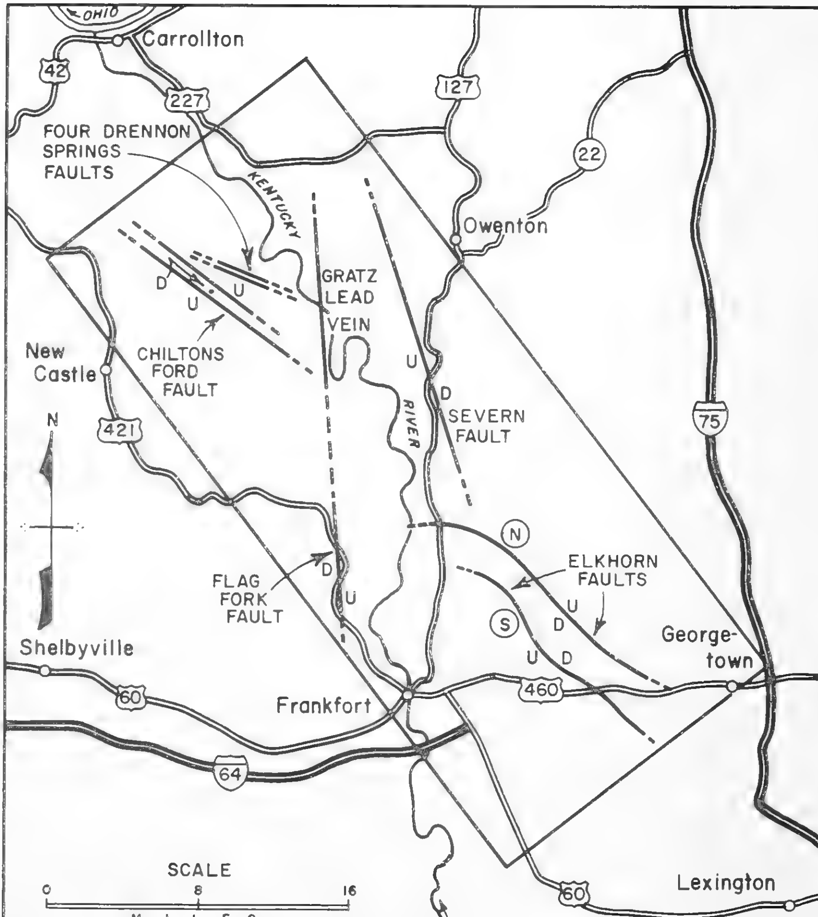
Somewhat prior to and during the progress of the field work which brought about the discovery of the Flag Fork Fault (12) in northwestern Franklin County, Kentucky, in the early autumn of 1964, the writer was moved, time and again, to recall the fact and the figure of the paired normal faults of N. W.–S. E. strike which Professor A. M. Miller found and carefully delineated while mapping the areal geology of the Georgetown, Kentucky, quadrangle (1) during the summer of 1912 for the fourth Kentucky Geological Survey. Along with a careful review of Professor Miller's work during the following summer when he continued the plotting of the paired Scott County faults and their graben into northeastern Flanklin County were he gave them termini in the valley of main Elkhorn in the vicinity of Peak's Mill, there came suddenly one day on the mid-waters of Flat Creek, a graphic mental picture of the several other normal faults not too distantly located to the northwest, well within the central drainage basin of the lower Kentucky River.

Closely following the completion of the field and manuscript work on the Flag Fork Fault, the writer turned to a precise plotting of each and all of the seven faults known to lie immediately to the north and northwest of Franklin County. When coupled with Professor Miller's two Elkhorn Faults, the writer's Camp Pleasant Branch Fault, which was discovered and mapped in the spring of 1962 as a northwesterly continuation of the northern Elkhorn disturbance, and the Flag Fork Fault, it was seen at once that this group of ten separate normal faults constituted a rectangular unit area involving parts of Scott, Franklin, Henry and Owen Counties. Owenton marks the boundary on the northeast, Frankfort and New Castle on the southwest, and Georgetown on the southeast. The imaginary rectangle embracing this highly disturbed Bluegrass area exhibits a length of 35 miles and a width of 10 miles. The total area thus demarked covers 350 square miles. The strike of the long boundary of the block is N. 38° W. A similar area of so intense and diverse normal faulting is not known to occur elsewhere in the Bluegrass area of Kentucky.

Beginning with Professor Miller's paired "Elkhorn Faults", each of the ten separate disturbances embraced within the rectangle as outlined, above, are listed below in the order of their discovery. They are also shown by name on the accompanying outline map of the area involved.



CLUSTER OF NORMAL FAULTING
IN THE
NORTHWESTERN BLUEGRASS REGION
OF
KENTUCKY
BY
WILLARD ROUSE JILLSON
GEOGOLIST AND ENGINEER
FRANKFORT, KY. - SEPT. 10, 1967

Fault	Described By	Year
1. North Elkhorn	A. M. Miller	1913
2. South Elkhorn	A. M. Miller	1913
3. Severn Fault	W. R. Jillson	1945
4. Camp Pleasant Branch	W. R. Jillson	1962
5. Chilton's Ford, Primary	W. R. Jillson	1965
6. Chilton's Ford, Secondary	W. R. Jillson	1965
7. Drennon Springs No. 1	W. R. Jillson	1965
8. Drennon Springs No. 2	W. R. Jillson	1965
9. Drennon Springs No. 3	W. R. Jillson	1965
10. Drennon Springs No. 4	W. R. Jillson	1965

The length, the stratigraphic offset and the computed displacement measured in feet varies, of course, with each listed fault. To avoid the tedious recitation of these prosy stratigraphic and structural details and other items of geologic importance appertaining, the following bibliography of primary sources is appended for the use of those whose interest in this subject exceeds the restricted measure of the outline given above.

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Adequate financing for the publication of *The Transactions* appears to be assured. Strong efforts are being made to bring the publication of *The Transactions* up to date by the end of 1969. The minutes and programs of the Academy's annual meetings have not been published since 1964. The editor feels that it is desirable to bring the published records of Academy affairs up to date.

THE FIFTY-FIRST ANNUAL MEETING OF THE KENTUCKY ACADEMY OF SCIENCE UNIVERSITY OF KENTUCKY, LEXINGTON, NOVEMBER 12-13, 1965

Minutes

The Annual Business Meeting of the Kentucky Academy of Science was called to order by President Hamann on Saturday Morning, Nov. 13, 1965 in Room N-10 of the Agricultural Science Center of the University of Kentucky.

The minutes of the 1964 meeting were read and approved.

A list of new members was read and approved by the academy.

The treasurer's report was given by J. Garner. It was moved and seconded that the report be accepted. The motion carried.

E. Fergus reported for the Visiting Scientists Program. He indicated that the number of visits requested by high school teachers last year were not as great as anticipated. Requests this year are running ahead of last year since to date there are 69 compared with 21 at this time one year ago. This years publicity was sent directly to the high school science teachers. The roster of available visiting scientists includes approximately 150 names. The present director of the program is resigning. An application to the National Science Foundation has been made to continue the program for another year.

President Hamann expressed the appreciation of the academy for the work of Dr. Fergus, as director of the Visiting Scientists Program for the past two years.

President Hamann noted that R. Jordan has resigned as Director of the Junior Academy, but is present to give his report of last years activities. His report, as accepted by the academy is attached to the minutes.

W. Owsley invited the academy to Kentucky Wesleyan College for next years annual meeting. J. Carpenter noted that the Centennial Celebration for T. H. Morgan is scheduled for Lexington next year. It was moved and seconded that the place for next years meeting be left in the hands of the executive committee. Motion carried.

M. Wharton reported on the annual meeting of the American Association for the Advancement of Science meeting at Montreal, Canada. She noted that the state academies of several nearby states are considerably larger and stronger than our academy. Perhaps one of our greatest needs is that of a permanent officer, such as an executive secretary or archivist. She commented on the role of the state academy and teacher certification. Many states have fewer requirements concerning "education courses" and thus students are able to take more work in "content" material. Dr. Wharton reported that she will be unable to attend the next Annual AAAS Meeting, and suggested that out President-elect, J. Carpenter, be our official representative. Motion was seconded and carried.

President Hamann reported on the difficulties previously encountered in the receipt of a $5,000 grant from the Department of Education, to our academy, for the Junior Academy and Science Youth Work. He noted the establishment of a Science Youth Activity Committee by F. Dickey. The only present representative of the original committee is D. Tapp.

President Hamann noted the lack of support of our academy by industry; probably only 3 industries are currently active. The possibility of academy support from the State Government level was raised.

It was moved and seconded that the Executive Committee of the Kentucky

Academy of Science be given authority to work on the above problems, and report at the next annual meeting. Motion carried.

H. LaFuze, chairman of the Resolutions Committee, read the following resolutions:

I. Whereas, the life of Dr. Alfred Brauer was taken on January 26, 1965,

Whereas, Dr. Brauer gave 50 years of his life to successful teaching and to inspiring his many students toward high goals,

Whereas, Dr. Brauer was nationally recognized for his research in biology as evidenced by his publication,

Whereas, Dr. Brauer was a member of the Kentucky Academy of Science for 38 years and served in various officers of the Academy for thirteen years,

Whereas, Dr. Brauer contributed freely of his time and efforts to the promotion of science and the Academy in all of the years of his association with it,
be it hereby resolved

1. that those present in this meeting of the Kentucky Academy of Science stand for a moment of silent tribute in memory of this great teacher and scientist who has passed from us,
2. that these resolutions be included in the minutes of this meeting and a copy be sent to his surviving wife.

II. Whereas, the University of Kentucky is celebrating its Centennial Year and
Whereas, the University of Kentucky has made outstanding contributions in scientific thought and leadership.

be it hereby resolved

1. that we, the Kentucky Academy of Science, congratulate the University for its one hundred years of service as an outstanding institution of education in Kentucky and our nation and for the promotion of science through teaching research.
2. that we, the Kentucky Academy of Science, commend the faculty and the administration who have made this progress possible,
3. that these resolutions be included in the minutes of this meeting and a copy be sent to the office of the president of the University.

It was moved and seconded that the academy accept these resolutions. Motion carried.

The nominating committee, W. Blackburn, F. Gailey, and H. Nollau, presented the following slate of nominees:

President-elect	R. Boyer
Vice-president	W. Read
Secretary	D. Lindsay
Treasurer	C. Hamann
Representative to AAAS Council	M. Wharton
Board of Directors	M. Heaslip
	L. Alexander

It was moved and seconded that the secretary cast a unanminous ballot for all nominees. Motion carried.

E. Browne reported on the status of the Kentucky Flora Project. He noted that work is in progress in various regions of the state and that G. Hunter has been added to the original committee. The report was accepted by the academy, with thanks.

The academy gave a vote of approval for the work of the past officers. The meeting was adjourned at 12:15 P.M.

Dwight M. Lindsay, Secretary

OFFICERS OF THE ACADEMY

President .... C. B. Hamann, Asbury College
President-Elect .... John M. Carpenter, University of Kentucky
Vice-President .... Robert M. Boyer, University of Kentucky
Secretary .... Dwight M. Lindsay, Georgetown College
Treasurer .... J.H.B. Garner, University of Kentucky
Representative to
A.A.A.S. Council .... Mary Wharton, Georgetown College
Editor of the Transactions .... R. E. Hampton, University of Kentucky

BOARD OF DIRECTORS

William B. Owsley .... to 1968
Alfred M. Wolfson .... to 1968
James Conkin .... to 1967
William Ehmann .... to 1967
Herbert Shadowen .... to 1966
Otis Wolfe .... to 1966
William Read .... to 1965
Richard Wiley .... to 1965

PROGRAM

Friday, November 12

All members are cordially invited to attend the Centennial Biological Conference Program. The Academy will hold no separate program on Friday.

6:30 p.m. Centennial Conference—K.A.S. Banquet, Main Ballroom, Student Center.

Saturday, November 13

8:30 a.m. Sectional Meetings (except as indicated)

10:45 a.m. Business Meeting

12:30 p.m. Luncheon, Small Ballroom, Student Center

Address by Dr. J. A. Chiscon, Assistant Professor of Biology, Purdue University.

Topic: "The Biology Curriculum"

BOTANY SECTION

J. H. B. Garner, Chairman
Gordon E. Hunter, Secretary

Jane S. Sisk. Department of Biological Sciences, Murray State College. A partial list of edible spermatophytes of Calloway County, Kentucky.

H. E. Eversmeyer. Department of Biological Sciences, Murray State College. Anatomy of *Paeonia albiflora* roots.

S. K. Majumdar and H. P. Riley. Department of Botany, University of Kentucky. Polyploidy and the evolution of its role in Haworthia.

G. E. Hunter. Department of Biological Sciences, Murray State College. Chromatographic documentation of interspecific hybridization in *Vernonia*: Composite.

E. T. Browne, Jr. Department of Botany, University of Kentucky. The vascular flora of Pike County, Kentucky.

R. E. Hampton. Departments of Botany and Plant Pathology, University of Kentucky. Intracellular distribution of polyphenol oxidase in *Nicotiana tabacum* and *Zea maize*.

CHEMISTRY SECTION

Darnell Salyer, Chairman
N. Thornton Lipscomb, Secretary

"Thermal Rearrangement of cycloalkano (α) pyroles," John M. Patterson and Soekani Soedigdo, University of Kentucky.

"Some Approaches to the Synthesis of Nitro Amines," John M. Patterson, Richard Johnson, and Michael W. Barnes, University of Kentucky.

"Solvent Dependence of Geminal Proton-Proton Coupling Constants," Richard H. Cox and Stanford L. Smith, University of Kentucky.

"Nuclear Magnetic Resonance Spectroscopy. A Study in Magnetic Non-equivalence," Richard H. Wiley, Thomas H. Crawford, J. M. McIntire, and H. L. Puckett, University of Louisville.

"Thermal Decomposition of Some Copolymers," Richard H. Wiley, Giovanni DeVenuto, and Frank E. Martin, University of Louisville.

"Characterization of Solvent-Modified Cation Exchange Resins," Richard H. Wiley and J. Thomas Badgett, University of Louisville.

"Azo Coupling in the Quinoline Series, "James J. Duffy and Ellis V. Brown, University of Kentucky.

"Determination of Trace Amounts of Antimony by Neutron Activation," J. T. Tanner and W. D. Ehmann, University of Kentucky.

"Bromine in Natural Materials by Activation Analysis," K. W. Lieberman and W. D. Ehmann.

"A Ternary Vapor-Liquid Equilibrium System Methanol-Benzene-Toluene," D. E. Burke and G. C. Williams, University of Louisville.

GEOLOGY-GEOGRAPHY SECTION

Lawrence L. Zelek, Chairman
David K. Hylbert, Secretary

Gordon W. Weir*, J. L. Gualtieri, and S. O. Schlanger, "Borden Formation (Mississippian) in South-and Southeast-Central Kentucky".

George C. Simmons*, "Pre-Middle Devonian and post-Middle Devonian faulting and the Silurian-Devonian unconformity near Richmond, Kentucky".

James E. Conkin and Barbara M. Conkin, "Foraminiferal Zonation of the Permian System of Tasmania".

Willard R. Jillson*, a list of four short papers follows:

a. "A Rare Iron Conglomerate, Occurring in Northeastern Hardin County, Kentucky".
b. "*Lingula nedularata,* Sp. Nov., Occurring in Central Powell County, Kentucky".
c. "A Limestone Conglomerate Occurring in the Eden Formation of Clark County, Kentucky.
d. "Fish Coprolites in the Onondaga Limestone of Eastern Central Kentucky".

Larry Ratcliff*, Thomas Sanders, J. R. Chaplin and Allen Lake, "The Progress Report on the Study of Stigmarian Root System in Elloitt County, Kentucky".

MICOBIOLOGY SECTION

Lucia Anderson, Chairman
J. N. Baldwin, Secretary

Protection of mice against Vesicular Stomatitis with homologous brain tissue vaccines. Mary B. Althauser and Isaac Ruchman, Department of Microbiology, University of Kentucky, Lexington.

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*speaker

The Nture of some beta-hemolysin mutants of *Straphylococcus aureus.* W. E. Allen and J. N. Baldwin, Department of Microbiology, University of Kentucky, Lexington.

Help! From the 7040—a statistical study of bacteriological data. M. Hotchkiss, O. F. Edwards and T. Redmon, Department of Microbiology, University of Kentucky, Lexington.

Biosynthetic control of isomaltase in *Saccharomyces cerevesiae.* J. W. Gorman, Department of Cell Biology, University of Kentucky, Lexington.

Transient "conventionalization" of gnotobiotic animals. R. F. Wiseman and H. A. Gordon, Departments of Microbiology and Pharmacology, University of Kentucky, Lexington.

Inhibition of phospholipid synthesis in *Escherichia coli* by antibiotics. B. J. Bloomfield, Department of Agronomy, University of Kentucky, Lexington.

PHYSICS SECTION

J. M. Pike, Chairman
Fletcher Gabbard, Secretary

Invited Papers:

The Interdependence of Astronomy and Physics. W. S. KROGDAHL, University of Kentucky. (30 minutes)

An Interdisciplinary Approach to Physics-Chemistry Teaching at the High School Level. HAROLD HANSON, *Centre College*

Contributed Papers:

Comments on the New Secondary School Curriculum, F. D. BOERCKER, *Georgetown College.*

Half-Lives and Yields of X-Rays from Thermal Fission of U^{235} and Pu^{239}. L. BRIDWELL, *Murray State College.*

The Field Effect of Tellurium Films. ADIL SHAMOO and MANUEL SCHWARTZ, *University of Louisville.*

The Structure of Hard Anodic Films of Aluminum. NICHOLAS MOSTOVYCH, University of Louisville.

Beta Decay of S^{37}, SUDIMAN WIRJOAMIDOJO and BERNARD D. KERN, *University of Kentucky.*

PSYCHOLOGY SECTION

Earl A. Alluisi, Chairman
Mary Ellen Curtin, Secretary

"Verbal mediation in reverse association: the role of temporal factors," Richard A. Kulp, HumRRO, Ft. Knox, Kentucky.

"The effect of stimulus range on the amount of information transmitted in absolute judgments of circular size," Patricia G. McGinty and Earl A. Alluisi, Psychology Department, University of Louisville.

"Transfer of inter-item associations from serial to paired—associate learning," Wayne L. Martin, Psychology Department, University of Kentucky.

"The effect of irrelevant information on absolute judgement at different levels of discrimination difficulty," Ben B. Morgan, Jr., Psychology Department, University of Louisville.

"Anonymous nuisance telephone calls to females," Frank Murray, Psychology Department, University of Kentucky.

"A comparison of learning curves in verbal and motor paired-associate tasks," Haywood S. Osborne, Jr., Psychology Department, University of Louisville.

"Fatigue as a subjective variable, or a scheme for relating three 'classical' measures of fatigue," Thomas J. Rebbin, Psychology Department, University of Louisville.

"Numerosity and the power function," Thomas J. Rebbin and Curtis L. Barrett, Psychology Department, University of Louisville.

"Gravity preference: discrimination between low levels of gravity by rats," W. Kirk Richardson and R. Chris Martin, Wenner Gren Laboratory, University of Kentucky.

"Interference effects and the retention of verbal material in process and reactive schizophrenia," Stanley Zupnick, Psychology Department, University of Louisville.

ZOOLOGY SECTION

H. E. Shadowen, Chairman

The Bats of Kentucky.
Wayne H. Davis and Roger W. Barbour, Department of Zoology, University of Kentucky.

The Effects of Low Temperatures upon Chick Embryos Treated *in ova*.
Mary McGlasson, Department of Biology, Eastern Kentucky State College.

The Establishment of Animal-Vegetal Polarity in the Oocytes of the Gastropod, *Ilyanassa obsoleta*. Arthur L. Applegate, Department of Biology, Western Kentucky State College.

Notes on the Spawning Behavior of *Semotilus atromaculatus* (Mitchell). Morgan E. Sisk, Department of Biology, Murray State College.

The Fishes of West Kentucky. Part I. Survey o the Fishes in Clark's River. Morgan E. Sisk.

The Occurrence of the Brown Recluse Spider, *Loxosceles reclusa* Gertsch and Mulaik, in western Kentucky.
Morgan E. Sisk.

The Effect of Colored Lights on Ingestion by the Immature Two-spotted Mite, *Tetranychus urticae*. T. N. Seay and J. G. Rodriguez, Department of Entomology and Botany, University of Kentucky.

Reaction of Various Species of Macrochelid Mites to Temperature and Humidity.
Pritam Singh and J. G. Rodriguez, Department of Entomology and Botany, University of Kentucky.

Some Experimental Infections of *Paragonimus westermani* in Cats.
J. M. Edney, Department of Zoology, University of Kentucky.

Multiple Genetic Perspectives of a Specific Locus in *Drosophila melanogaster*. Sara Frye.

THE FIFTY-SECOND ANNUAL MEETING OF THE KENTUCKY ACADEMY OF SCIENCE KENTUCKY WESLEYAN COLLEGE, OWENSBORO

November 11-12, 1966

Minutes

The Annual Business Meeting of the Kentucky Academy of Science was called to order by President Carpenter on Saturday Morning, November 12, 1966, in the Baptist Student Union Building of Kentucky Wesleyan College.

The minutes of the 1965 meeting were read and approved.

The treasurer's report was given by C. Hamann. It was moved and seconded that the report be accepted. The motion carried.

President Carpenter commented on the financial status of the Academy. He urged prompt payment of membership dues. He noted the need of a paid executive officer of the academy that could devote more time to acadmy work, and thus possibly increase income to the Academy. It was suggested that

Academy income might be increased by the sale of advertising space in the Transactions. It was moved and seconded that this possibility be explored by the editor. The motion carried.

An increase in annual dues was considered. It was moved and seconded that an increase in dues be considered by the Executive Committee. The motion carried.

It was suggested that we explore the possibility of printing of the Transactions in a more economical manner, such as the employment of a different printer. Offset printing was discussed. Two people voiced the opinion that offset printing might hamper the quality of the Transactions. Consideration was given to publishing only one issue of the Transactions per year. Objections were raised to this idea. An approach to industries by letter for support of Academy work, was proposed.

Use of the AAAS Research Grant was discussed. Since AAAS has not yet notified us of the availability of such money, requests by academy members for Research Grants will be received until January 1, 1967. The use of this money for high school projects was considered.

E. Browne, a member of the Resolutions Committee, read the following resolutions:

Be it resolved that the Kentucky Academy of Science go on record as expressing its appreciation to the President of Kentucky Wesleyan College, Doctor Harold P. Hamilton, the local arrangements committee, the faculty, staff and all others concerned for a most successful meeting of the Academy.

Furthermore, be it resolved that the Kentucky Academy of Science go on record as expressing its appreciation to Dr. John Carpenter, Retiring President, Dr. Robert Kuehne, Dr. Leon W. Weinberger, Col. Joseph L. Tucker, Dr. Robert A. Lauderdale, Prof. A. Dan Tarlock, Dr. Edwin B. Kurtz and Dr. Wingate A. Lambertson for their role in the Water Resources Symposium or otherwise in the program of the annual meeting.

Be it resolved that this Committee thanks the membership of the Kentucky Academy of Science for their interest in the organization as evidenced by their attendance and participation in the syposium and section programs.

Mary Ellen Curtin, Chairman
Morgan Sisk
Edward T. Browne, Jr.

It was moved and seconded that the Academy accept these resolutions. Motion carried.

A list of new members was presented and approved.

R. Barbour, Director of the Visiting Scientists Program, reported on its activities. He noted that thus far 16 visits have been completed and that there is money available for 60 more visits. There are few requests for visitors from high school in the far western portion of the state, or from Southeastern Kentucky. The program will be terminated at the end of this school year.

It was moved and seconded that Life Membership Dues be raised from \$30.00 to \$50.00 and that Regular Membership Dues be raised from \$3.50 annually to \$4.00 annually, beginning with the 1967-68 school year. The motion carried.

The establishment of a Science Education Section of the Academy was considered. Notification of Academy Members, by the secretary, on September 28 was considered to meet the constitutional requirement on the establishment of new sections. It was moved and seconded that a Science Education Section of the Academy be established. Motion carried.

Meeting places for future years were considered. Western Kentucky University invited the Academy to meet with them in 1968 and Murray State University presented an invitation for 1969.

R. Kuehne, Chairman of the Nominating Committee, presented the following slate of nominees:

President-elect	P. Sears
Vice-president	O. Richardson
Secretary	R. Larance
Treasurer	C. Hamann ffl
Representative to A.A.A.S. Council	M. Wharton
Board of Directors	K. Hussung
	G. Quinto

It was moved and seconded that this group be elected by acclamation. Motion carried.

The meeting was turned over to President R. Boyer who congratulated the retiring president and executive committee for the work they have accomplished for the academy. President Boyer announced the appointmnt of Dr. Morris Taylor as Director of the Junior Academy.

Dwight M. Lindsay, Secretary

OFFICERS OF THE ACADEMY

President .... John M. Carpenter, University of Kentucky
President-Elect .... Robert M. Boyer, University of Kentucky
Vice-President .... William G. Read, Murray State Univresity
Secretary .... Dwight M. Lindsay, Georgetown College
Treasurer .... C. B. Hamann, Asbury College
Representative to
A.A.A.S. Council .... Mary Wharton, Georgetown College
Editor of the Transactions .... Raymond E. Hampton, University of Kentucky

BOARD OF DIRECTORS

Margaret B. Heaslip .... to 1969
Lloyd E. Alexander .... to 1969
William B. Owsley .... to 1968
Alfred M. Wolfson .... to 1968
James Conkin .... to 1967
William Ehmann .... to 1967
Herbert Shadowen .... to 1966
Otis Wolfe .... to 1966

PROGRAM

Friday, November 11

4:00 p.m. Registration and Coffee Hour
Scientific Exhibits

7:00 p.m. Banquet, Baptist Student Union Building
Welcoming Remarks, Dr. Harold P. Hamilton, President, Kentucky Wesleyan College

8:00 p.m. Symposium: Water Resources

Moderator:

Dr. R. A. Kuehne, Assistant Professor of Zoology, University of Kentucky

Speakers:

Dr. Leon W. Weinberger, Assistant Commissioner for Research and Development, Federal Water Pollution Control Administration, Washington, D. C.

Col. Joseph L. Tucker, Division of Water Resources, Kentucky Department of Natural Resources.

Dr. Robert A. Lauderdale, Director, University of Ky. Water Resources Institute.

Prof. A. Dan Tarlock, Asst. Professor of Law, University of Kentucky.

Saturday, November 12

8:15 a.m. Sectional Meetings

11:00 a.m. Annual Business Meeting

12:30 p.m. Buffet Luncheon, Baptist Student Union Building

Speaker:

Dr. Wingate A. Lambertson, Executive Director, Kentucky Science and Technology Commission

BOTANY SECTION

Harold Eversmeyer, Chairman
Robert Larance, Secretary

Election of Officers

Megasporogenesis in *Laburnum anagyroides* Medic.—A case of Bisporic Development in Leguminosae. David H. Rembert, Jr., Department of Botany, University of Kentucky.

Some Species of Vascular Plants New to Kentucky. Edward T. Browne. Department of Botany, University of Kentucky.

Some Interesting Chromosomal Translocations in *Haworthia.* H. P. Riley, S. K. Majumdar, and R. E. Hammack, Department of Botany, University of Kentucky.

Fungi in Stream Draining Strip-mined Forest Area. Donald Nash and Ralph H. Weaver, Department of Microbiology, University of Kentucky.

CHEMISTRY SECTION

N. Thornton Lipscomb, Chairman
Joseph W. Wilson, Secretary

Conductivity Studies in Chloroform: The System $(C_6H_5)_4$ AsCl-$HCCl_3$. Peter X. Armendarez, Tom Gerteisen, and Donald O'Bryan, Brescia College.

Chemistry of Cyclopenin. John L. Wong, Preston Martin, and Henry Rapoport, University of Louisville.

Extended Huckel Molecular Orbital Calculations on Reactivity Sites in Be$(acac)_2$. J. Steele and D. H. Williams, University of Kentucky.

Preparations and Properties of the Ferrate Ion, J. Riley and D. H. Williams, University of Kentucky.

Application of Infra-red Analysis to the Willgerodt Reaction. Hartley C. Eckstrom, John Bates, and Ellis V. Brown, University of Kentucky.

A minoketone Rearrangements, A Kinetic Study. C. L. Stevens, H. T. Hanson, and K. G. Taylor, University of Louisville.

GEOLOGY-GEOGRAPHY SECTION

Zelek L. Lipchinsky, Chairman
David K. Hylbert, Secretary

Deep Sea Managanese: Resource or Phenomenon? Dr. David B. Brooks, Berea State College.

North American Lower Devonian Foraminifera and Their Stratigraphic Implications. Dr. James E. Conkin and Barbara M. Conkin, University of Louisville.

Intermission

Business Session and Election of Officers

On Shell Structure and Classification of Pentameroidea (Brachiopoda). Dr. K. Lal Gauri, University of Louisville.

Sedimentation Studies of theOhio River at Louisville, Kentucky. Dr. Robert Bruce Moore, University of Louisville.

PHYSICS SECTION

Otis K. Wolfe, Chairman
Fletcher Gabbard, Secretary

Invited Papers

Radioastronomy in Space. N. Frank Six, Western Kentucky University.

Some Heavy Ion Experiments with an Emperor Tandem Accelerator. L. B. Bridwell, Murray State University.

Contributed Papers

A Study of Solidification and the Effects of Homogenization for the Quasi-Binary Al-Mg_2 Si Alloy. Nicholas Mostovych and Clyde F. Casey, University of Louisville.

Charged Particle Tracks in Cellulose Acetate Butyrate. Thomas D. Strickler, Berea College.

Thermoluminescence Color Centers and Electrical Conductivity of Gamma Irradiated Lithium Fluoride. William G. Buckman, Kentucky Wesleyan College.

Open Orbit and Magnetic Breakdown in White Tin. Kiron C. Bordoloi, University of Louisville.

PSYCHOLOGY SECTION

Mary Ellen Curtin, Chairman
Richard M. Griffith, Secretary

Panel Discussion

"The Emotionally Disturbed Child in the Classroom"

Moderator:

Dr. Frank Kodman, Jr., Chairman, Department of Psychology, Murray State University

Panelists:

Mr. I. T. Baldwin, Psychological Associates, Ltd., Lexington (consulting psychology)

Ms. Charlotte Baumgarten, Counselor, Owensboro City Schools (guidance and counseling)

Ms. Mary Ruth Dodson, Elementary Supervisor, Owensboro City Schools (supervisory)

Dr. Kenneth Estes, Superintendent, Owensboro City Schools (administration)

Miss Oreva Grey, School Psychologist, Owensboro City Schools (school psychology)

Dr. Charles Homra, Assistant Professor of Psychology, Murray State University (school psychology)

SCIENCE EDUCATION SECTION

Barbara Tea (Acting Chairman)
Dorothy Tapp (Acting Secretary)

Business Meeting

Background of the Kentucky Academy of Science. Robert Boyer, University of Kentucky.

Trends in the New Science Curricula. Edwin B. Kurtz, A.A.A.S.

Winning Physical Science Discussion Paper. Junior Academy of Science.
Winning Biological Science Discussion Paper. Junior Academy of Science.

ZOOLOGY SECTION

Lloyd E. Alexander, Chairman
Liza Spann, Secretary

Election of Section Officers

Analysis of Dental Variation in Wild Populations of the House Mouse. James T. Wallace, Eastern Kentucky University.

Food of the Creek Chub, *Semotilus atromaculatus* (Mitchell), from Western Kentucky. Morgan E. Sisk and Paul L. Smith, Murray State University.

Morphology and Histology of the Stomach of the White Shrimp *Penaeus fluviatilis* (Say, 1817). Noble Roberts, Campbellsville College.

A Brief Description of a "Fertilization inhibitor" in *Lytechinus variegatus.* Robert E. Daniel, Murray State University.

Cytogenetic Analysis of a Double-Marker Mutant in *Drosophila melanogaster.* Sarah H. Frye, Irvine, Kentucky.

Albino Common Snapping Turtle from Kentucky. Branley A. Branson, Eastern Kentucky University.

Comments on the Olfactory Apparatus in the Cyprinid Genus *Hybopsis.* Branley A. Branson, Eastern Kentucky University.

A Search for *Trypanosoma cruzi* in Kentucky Opossums. John V. Aliff, University of Kentucky.

Ecological Genetic Studies on a Population of *Drosophila melanogaster* in Amherst, Massachusetts. James E. Carver, Jr., University of Kentucky.

Hormones and Evolution. Edwin Dale, University of Kentucky.

The Nature and Occurrence of *Ophridium versitale* in Kentucky. Allen L. Lake, Morehead State University.

THE FIFTY-THIRD ANNUAL MEETING OF THE KENTUCKY ACADEMY OF SCIENCE THE UNIVERSITY OF LOUISVILLE, LOUISVILLE NOVEMBER 10-11, 1967

Co-Hosts: Dean John W. Dillon, Graduate School
Dean William C. Huffman, University College.

The annual business meeting of the Kentucky Academy of Science was called to order by President Boyer on Saturday morning, November 11, 1967 at 11:30, in the Lincoln Room, University center, at the University of Louisville, Louisville, Kentucky.

Minutes of the Fall Meeting, 1966, were distributed to members attending the business meeting by the secretary, R. Larance. A motion was made and seconded to approve the minutes of the 1966 meeting. The minutes were approved.

President Boyer called upon H. Howell, chairman of the Auditing committee, to make his report. He read the following statement: "We, the undersigned members of the Auditing committee, have gone over the books of the Treasurer of the Society and have found them to be accurate with the exception of a minor error of $3.50 make on a deposit slip by the bank." Signed by Henry H. Howell and E. C. Morris.

The Treasurer, C. B. Hamann, distributed the financial report for the Society. A motion was made and seconded that the Auditing report and the Treasurer's report be approved. The motion passed. (This report is filed in the Secretary's book).

O. Richardson, chairman of the AAAS Grant Committee, reported that four applications for the AAAS Grant had been received and that $120.00 had been granted to Sister Virginia Heines, Catherine Spalding College, for research on Fractionation of Ascites Tumor Supernatant on Sephadex bed; and $40.00 to Dr. Eugene E. Shroeder, Eastern Kentucky University, for research on Sun-Compass Orientation in Subadult Anurans.

R. Kuehne, chairman of the resolutions committee read the following resolutions:

Resolution #1. A Letter of Thanks. . . .

The Kentucky Academy of Science expresses its great appreciations to the University of Louisville for the use of facilities in meeting and dining we have enjoyed during the course of the 1967 Fall Meeting of the Academy.

The Academy extends its sincere thanks to Dean John Dillion, Dean of the Graduate School, University of Louisville, Official co-hosts for the meeting, for the warmth of hospitality present in the planning and carrying-out of our meetings here at Louisville.

Special thanks are due to the Site Committee from the Academy: Dean John Dillon, Dr. J. W. Brown, Dr. James E. Conkin, and Dr. Thomas H Crawford for the considerable work and effort expended in the planning and execution of the arrangements which have made our meetings so pleasant, efficient and profitable.

Resolution passed.

Resolution #2. Deaths. . . .

The Kentucky Academy of Science sadly notes the death of several members in the year preceding this fifty-third annual meeting. The Academy requests that the Secretary record the names of the deceased upon the minutes of this meeting and indicate that our respect was paid by silently standing together.

Resolution passed.

Resolution #3. Red River Gorge. . . .

Whereas the United States Army Corps of Engineers has been empowered to construct a multipurpose dam which will flood the gorge of Red River in parts Powell and Menifee counties, Kentucky, and

Whereas the impoundment would destroy one of the truly wild rivers left in the eastern United States, seriously damaging cr eradicating the attendant flora and fauna, and irreparably impair the scenic grandeur of the area, and

Whereas the impoundment will flood the scenic road used by thousands of visitor annually, and will stop or impair the growth of many forms of outdoor recreation, and will diminish the scientific and educational values presently found in the gorge, and

Whereas there are alternative methods of flood control for the lower reaches of Red River, and alternative sites within the Kentucky River basin for dams to supply water to downstream cities and towns,

Therefore, be it resolved that the Kentucky Academy of Science at this, its Fifty-Third Annual Meeting, recommend that construction of said dam be stopped, and that the various alternatives, including the Red River area, be given due deliberation.

Further be it resolved that a copy of this resolution be spread upon the minutes of the Academy, and copies of the resolution be sent to the Kentucky Members of the United States Senate and House, the Secretary of the Interior of the United States, the Commanding Officer of the

United States Army Corps of Engineers, and to the Governor, and the Governor-Elect of Kentucky.

This resolution *was approved* after considerable discussion without voiced opposition from the 73 Academy members attending the Businesss meeting.

Resolution #4.

Whereas the Kentucky Academy of Science is composed of responsible scientists and educators who are prepared to serve the best interests of th citizens of the Commonwealth, and

Whereas the proper management and utilization of the natural resources of the Commonwealth are paramount importance to the progress, and

Whereas the proper management and utilization of the natural resources of the Commonwealth are paramount importance to the progress, and

Whereas the problems of maintaining desirable quality of air, soil and water and other environmental resources are assuming ever greater proportions and importance to the people of the Commonwealth

Therefore be it resolved that the Academy go on record as favoring intelligent, long-range resource management.

It was further resolved that the Kentucky Academy of Science empower the President and Executive Committee to investigate the possibility of establishing the appropriate mechanism for acheiving the above objectives.

Resolution passed.

A motion was made, seconded and passed that M. Wharton, AAAS Representative requests the AAAS council to recommend to the proper authorities a delay in the construction of the Dam in the Red River Gorge.

President Boyer stated that an Anthropology Section had been organized at this annual meeting and the a report to all members stating this be made 30 days prior to the 1968 annual meeting.

The nominating committee, composed of L. Alexander, P. Panzera, and R. Weaver, with L. Alexander reporting, presented to the Academy the following slate of nominees:

President Elect	O. Richardson
Vice President	L. Krumholz
Secretary	R. Larance
Treasurer	C. Hamann
Board of Directors	J. Carpenter
	W. Clay

Note: M. Wharton was elected in 1966 to a two year term as AAAS Representative. She said that this would be the last year for her to hold office. She wishes to give it up to someone else.

It was moved, seconded, and approved that the nominees be elected by acclamation.

C. Hamann, Treasurer, stated that there was a small sum of money ($83.37) designated by the Academy to help furnish the Thomas Hunt Morgan Room in Lexington. This money, most of which was donated several years ago and earmarked for this purpose is in a First Federal Savings and Loan Association Account. C. Hamamn suggested that a committee be appointed to study and decide what the Academy should place in the Room.

M. Taylor, Director of the State Junior Academy, made a few brief remarks concerning the Junior Academy. Enthusiasm is good he remarked and a meeting is planned in late November with the members for the purpose of planning the year's activities.

D. Lindsay, Georgetown College, gave an official invitation to the Academy to hold its 1970 annual Fall Meeting on the Campus of Georgetown College, Georgetown, Kentucky. President Boyer accepted the invitation.

President Boyer stated that the annual Fall Meeting of the Society would be held in 1968 on the Campus of Western Kentucky University.

The meeting was adjourned at approximately 12:30 P.M.

OFFICERS OF THE ACADEMY

President	Robert M. Boyer, University of Kentucky
President-Elect	Paul G. Sears, University of Kentucky
Vice President	Orville Richardson, Kentucky Wesleyan College
Secretary	Robert S. Larance, Eastern Kentucky University
Treasurer	C. B. Hamann, Asbury College
Representative to A.A.A.S. Council	Mary Wharton, Georgetown College
Director, Junior Academy	Morris D. Taylor, Eastern Kentucky University
Editor of the Transactions	Raymond E. Hampton, University of Kentucky

BOARD OF DIRECTORS

Karl F. Hussung	to 1970
Grace Quinto	to 1970
Lloyd E. Alexander	to 1969
Margaret B. Heaslip	to 1969
William B. Owsley	to 1968
Alfred M. Wolfson	to 1968
James Conkin	to 1967
William Ehmann	to 1967

PROGRAM

Friday, November Tenth

4:00 p.m. Registration and Coffee Hour, Exhibits, Bigelow Hall, University Center

7:00 p.m. Banquet, Faculty Dining Hall, University Center

Welcome: Vice President William C. McGlothlin, University of Louisville Panel Symposium on Air Pollution

Moderator: Dr. Mark Luckens, College of Pharmacy, University of Kentucky

Panel Speaker: Dr. Raymond Smith, Chief, Quality and Emission Data Program, National Air Pollution Control Program, United States Public Health Service

Panel Speaker: Dr. Robert J. Horton, Chief, Health Effects Research Program, National Air Pollution Control Program, United States Public Health Service

Panel Speaker: Mr. Harold Hodges, Director, Air Polution Control Program, Kentucky State Department of Health

10:00 p.m. Social Hour, Albert Pick Motel

Saturday, November Eleventh

8:15 a.m. Sectional Meetings

11:30 a.m. Business Meeting

1:00 p.m. Luncheon Meeting, Faculty Dining Hall, University Center
Speaker: Mr. John E. Pearce, Louisville Courier-Journal and Times

ANTHROPOLOGY SECTION

Henry Dobyns, Chairman Pro-tem Organizational Meeting

BOTANY SECTION

Edward T. Browne, Jr., Chairman
Charles J. Isbell, Secretary

Election of Officers

Lobelia inflata in Appalachia
Arnold Krochmal, U.S. Forest Service, Northeastern Forest Experiment Station, Berea College

A Stalk Rot of Corn due to a specific soil Environment, Dr. Harold E. Eversmeyer, Department of Biological Sciences, Murray State University

Trilisa odoratissima, a useful Southern Plant, Arnold Krochmal, U.S. Forest Service, Northeastenr Forest Experiment Station, Berea College

CHEMISTRY SECTION

Joseph W. Wilson, Chairman
B. E. McClellan, Secretary

Chemistry of Methoxyprimidine. John L. Wong and David S. Fuchs, Department of Chemistry, University of Louisville.

Carcinogenic Activity of the Methyl Substituted 5'–(4-Dimethylaminoazo) quinolines. Ellis V. Brown and James J. Duffy, Department of Chemistry, University of Kentucky.

Photochemical Reduction of an alpha-Beta-Acetylenic Ester. Vernon S. Stubblefield and Joseph W. Wilson, Department of Chemistry, University of Kentucky.

Stereochemistry of Vapor Phase Dehalogenation of *Meso-and D-L-2* 3-Dibromobutane with Zinc. Marshall Gordan and James V. Hay, Department of Chemistry, Murray State University.

Enhancement of Atomic Absorption Sensitivity Using Extractive Processes. B. E. McClellan and D. A. Darnall, Department of Chemistry, Murray State University.

A Novel Copper (II, Complex. A. Patel, G. Geffroy, J. Brooks, and T. H. Crawford, Department of Chemistry, University of Louisville.

Preparative Methods for Anhydrous Rare Earth Chelates. J. M. Koehler, N. J. Hornung and W. G. Bos, Department of Chemistry, University of Louisville.

On the Use of Organ/Body Ratios as an Index of Toxicodynamic Response. Johanna R. Wattimena and Mark M. Luckens, College of Pharmacy, University of Kentucky.

Enzyme Patterns in Acute Intoxication with Organo-chlorine Insecticides. Mark M. Luckens and Kirk I. Phelps, College of Pharmacy, University of Kentucky.

A Study of Photochromic Spiropyrans Using NMR Techniques. J. T. Gleaves, J. C. Deck and J. P. Phillips, Department of Chemistry, University of Louisville.

Photochemistry of Methyl 4, 4, 4-Triphenyl-2-butynoate. Joseph W. Wilson and Kurte L. Huhtanen, Chemistry Department, University of Kentucky.

Election of Officers

GEOLOGY-GEOGRAPHY SECTION

David K. Hylbert, Chairman
Barbara M. Conkin, Secretary

Election of Officers

Upper Devonian (Saverton Formation)

Arenaceous Foraminifera from N. E. Missouri and Western Illinois. Neil Whitehead, III. Department of Geology, University of Louisville.

Recent changes in Urban Land Use-Some Comparisons between Tropical S. E. Asia and Midwestern United States. W. A. Withington, Geography Department University of Kentucky and Dennis Spetz, Division of Social Sciences, University of Louisville.

Neogene Stratigraphy Gulf and Atlantic Costal Plains and Continental Shelves: Past, Present, and Future. Jules R. DuBar, Geoscience Department, Morehead State University.

Mississippian Species of the Problematic Genus *Palaeacis* and its Stratigraphic Value. James E. Conkin, Department of Geology, University of Louisville.

Stratigraphy of the Newman Limestone in the Bangor Quadrangle, Kentucky: A Preliminary Report. John C. Philley and David K. Hylbert, Geoscience Department, Morehead State University.

Middle Devonian (Hamiltonian) Arenaceous Foraminifera from northwestern Kentucky and southern Indiana. Norman Thomas, Department of Geology, University of Louisville.

Dynamics of Recent Urban Land Use Change in S. E. Asia. W. A. Withington, Geography Department, University of Kentucky.

Patterns of Land Use Change in the "College Town." Dennis Spetz, Division of Social Science, University of Louisville.

PHYSICS SECTION

Manuel Swartz, Chairman
Fletcher Gabbard, Secretary

Some Comments on Myths. F. H. Waldemar Noll. Berea College.

Study of Ordering in $Li_{.5}$ $Fe_{2.5}$ 0_4 Ferrite by Mossbauer Effect. K. Bowers and P. J. Ouseph. University of Louisville.

Study of Ordering of $Li_{.5}$ $Fe_{1.25}$ $Cr_{1.25}$ 0_4 through Compensation in Temperature. P. J. Ouseph and K. Bowers. University of Louisville.

Triangular Ferrimagnetic Structure of Ni Fe_2 0_4. P. J. Ouseph University of Louisville.

A Differential Planetary Gear System of Eight Gears with a Speed Reduction of 64 Million. J. G. Black, Eastern Kentucky University.

Satellite Band Spectroscopy and Atomic Interaction Potentials. Joel A. Gwinn. University of Louisville.

Gamma-gamma Coincidences Following Beta Decay of 48_{Sc}. Herbert D. Rice and Bernard D. Kern. University of Kentucky.

Interferometric Measurement of Ultrasonic Velocity Absorption in Gas Mixtures. Ralph L. Drury and Carl E. Adams. University of Louisville.

Progress Report of KAPT Advisory Committee on Physics Education. Ted M. George, Chairman, KAPT Advisory Committee, Eastern Kentucky University.

PSYCHOLOGY SECTION

Mary Ellen Curtin, Chairman
Richard M. Griffith, Secretary

Paper Reading Session

Chairman Rev. Joseph H. Voor

Perceptual Motor Maturation and Language Development in Young Children. Louise Stapp, Kentucky Southern College.

The Effect of Specific Auditory Background on Apparent Duration Through Reproduction. Thomas Thieman, Bellarmine College.

Voice Set Incongruity and the Distribution of Atteniton. Grace Bauer and John Robinson, University of Louisville.

Hypnotic Susceptibility and Visualization Skill. William Schweisheimer, University of Louisville.

Hypnotic Control of Pain. Roger Gardner, University of Louisville.

Effects of Interlist Rule Order and Solution—word Categorizability on Learning Codeable Trigrams. John A. Robinson and Barry Rabin, University of Louisville.

Election of Section Officers

Panel

Psychology Masters Programs in New State Universities: Plans, Problems and Prospects.

Chairman: Earl A. Alluisi, University of Louisville.
Panelists: Frank Kodman, Jr., Murray State University
Bradley L. Clough, Morehead State University
Harry R. Robe, Western Kentucky University
James A. Lee, Eastern Kentucky University
Discussant: John R. Binford, University of Louisville

SCIENCE EDUCATION SECTION

Barbara Tea, Chairman
Dorothy Tapp, Secretary

Election of Officers

Discussion of New Media in Science Teaching

ZOOLOGY SECTION

Hunter M. Hancock, Chairman
Beatrice Evans, Secretary

Election of Officers

Animal Vegetal Polarity in Spirally Cleaving Eggs: Asymmetry of P^{32} Uptake in the Oocytes of the Marine Gastropod, *lyanassa obsoleta.* Arthur L. Applegate, Western Kentucky University.

Comparative Study of Cutaneous Gas Exchange in two Iguanid Lizards. R. R. Schuletus and E. C. Crawford, University of Kentucky.

Identification of some Fatty Acids in the two-spotted Spider Mike, *Tetranychus urticae*. Koch, Meredith Wallings, David C. White and J. G. Rodriguez, University of Kentucky.

A Tangential Method for Determining the Duration of Lag Phase in Mass Culture of *Tetrahymena pyriformis*. HSM. Robert E. Daniel and Sarah E. Plummer, Murray State University.

Variations in Ultraviolet Sensitivity During the Cell Cycle of *Tetrahymena pyriformis* HSM. Robert E. Daniel, Murray State University.

How Long, O Lord, How Long. Roger W. Barbour, University of Kentucky.

Two New Slugs. (*Gastropoda philomycidae*) from Kentucky. Branley A. Branson, Eastern Kentucky University.

Comments on *Percina cymatotaenia* (Red River Drainage) and *Percina oxyrhyncha* (Big Sandy River) in Kentucky. Branley A. Branson and Donald Batch, Eastern Kentucky University.

Two Different Types of Follicle Cells Found in Ovary of *Bombus*. Rudolph Fulton, Eastern Kentucky University.

Chromosome Breakage in the Yellow-Achaete Region in Drosophila. Sara H. Frye, Irvine, Kentucky.

Research notes on the life cycle of *Cathaemasia reticulata* (looss) in the Eastern Belted Kingfisher. John V. Aliff, University of Kentucky.

The Occurrence of *Zapus hudsonicus*, the Meadow Jumping Mouse, In Madison County, Kentucky. James T. Wallace, Eastern Kentucky University.

The Production of Immunity to *Trichinella spiralls* in Pigs. J. M. Erney, University of Kentucky.

THE FIFTY-FOURTH ANNUAL MEETING OF THE KENTUCKY ACADEMY OF SCIENCE WESTERN KENTUCKY UNIVERSITY, BOWLING GREEN

NOVEMBER 1-2, 1968

Host: Dean Marvin W. Russell, Ogden College of Science and Technology.

Minutes

The annual business meeting of the Kentucky Academy of Science was called to order by President Paul Sears on Saturday morning, November 2, 1968 at 11:45, in room 129 of the Kelly Thompson Science complex, Western Kentucky University, Bowling Green, Kentucky.

Minutes of the Fall Meeting, 1967, were distributed to members attending the business meeting by the secretary, R. Larance. A motion was made and seconded to approve the minutes of the 1967 meeting. The minutes were approved.

The treasurer, C. B. Hamann distributed the financial report for KAS. A motion was made and seconded that the Treasurer's report be approved. The motion was passed. (This report is filed in the Secretary's book).

President Sears called upon the Auditory Committee for its report. H. H. Howell presented this report. A motion was made and seconded to approve the report. Motion passed. (This report is filed in the Secretary's book).

President Sears gave a report on the Transactions of KAS. He stated that Vol. 27 should be mailed soon after the Fall meeting, and that Dr. W. Wagner, University of Kentucky will become the new Editor. The President stated that the University of Louisville and the University of Kentucky had donated $350.00 each to the Academy in support of the Transactions of the Academy.

R. Larance, Secretary of KAS, presented a report from the Executive Committee. The establishment of an Anthropology Section was reviewed and it was stated that the Executive Committee had approved of the new section. The final step for the approval of Anthropology as becoming a Section of KAS needed ¾ vote of approval from members attending the Annual Fall meeting (1968). The Secretary made a motion whereby Anthropology would become an official segment of the Academy. The motion was seconded and passed. Anthropology became an official Section of KAS.

The Secretary stated that the Executive Committee had discussed in detail and had given much thought to membership of Academy—particularly to "Industrial and Business membership". This stems from the fact that the Academy lacks "Industrial membership" proportional to industry in the state of Kentucky. With this in mind a motion was made by the Secretary on behalf of the Executive Committee to change By-laws #4 (as amended) to read from Industrial and Business membership—$250.00 annually to read "Contributing Membership" with annual dues being $50.00 or in multiples of $50.00. The motion was seconded and passed.

At the Annual meeting, 1967, considerable discussion was centered around the establishment of a standing committee in "Man and His Environment." Such a committee could consider whether or not a dam ought to be put across a particular stream, air pollution, stream pollution, and differential utilization of human as well as natural resources could be considered by this committee. The Secretary, representing the Executive Committee, made a motion to establish such a committee and that the incoming president of KAS appoint this standing committee on "Man and His Environment."' The motion was seconded and passed.

President Sears informed the members that the Executive Committee had declared upon two of its members the Life honorary membership, the first for the Academy. This is in recognition for their long tenure of service to the Academy. The two members are Dr. W. R. Jillson and Dr. Harvey B. Lovell.

Thirty-nine new members were received into full membership of the Academy.

Professor Orville Richardson, Chairman of the AAAS Grant Committee, reported that there were several applications made for the $140.00 AAAS Grant and that the committee had awarded the full amount ($140.00) to Professor Harold W. Elmore, Western Ky. University to further his research on "The Ecology and Physiology of Germination in *Isoetes engelmanni* A. Br.

Dr. Kuehne, Chairman of the resolutions committee presented the following (two) resolutions:

RESOLUTION

Because Western Kentucky University has graciously served as the host institution for the fifty-fourth annual meeting of the Kentucky Academy of Science and because Dean Marvin W. Russell, Ogden College of Science and Technology, and the members of the Site Committee, Lynn B. Greeley, Chairman, John W. Reasoner, Herbert E. Shadowen, Robert H. Foster, Frank Six, Earl Murphy, Cliften Bryant and Harry R. Robe have all worked so diligently to make the meeting a success, be it resolved that the Kentucky Academy of Science express its appreciation to Western Kentucky University and the above named individuals, and that the Secretary of the Academy so inform them Resolution passed.

RESOLUTION

Be it resolved that the Kentucky Academy of Science takes note of the death of several loyal members during the year preceding this fifty-fourth annual meeting, that the members make an appropriate show of respect and that this be so recorded in the minutes by the Secretary. Resolution passed.

The Academy stood with bowed heads in silence for a few seconds in respect for those members who had passed from us through death.

President Sears stated that he had appointed Mary Wharton and John Carpenter to review and study the T. Hunt Morgan Gift Fund and report to the Academy next year their recommendations as to how the Fund could best be used.

Eastern Kentucky University, Richmond, Kentucky extended to the Academy an invitation to hold its Fall meeting on its campus in 1971. Transylvania College extended an invitation to the Academy for its Fall meeting in 1972. These invitations were accepted. The President then stated that next year's meeting would be held on the campus of Murray State University and that in 1970 the Fall meeting would be held at Georgetown College, Georgetown, Ky.

Dr. Kuehne spoke on matters dealing with the Red River gorge and other matters of interest concerning natural environment. It was brought out in the discussion and concluded that the Academy's participation in such matters would be through the committee on "Man and his Environment." The committee would work with other interested groups in Kentucky and bring information and recommendations to the Academy.

The nominating committee reported the following slate of officers for 1969 to the members.

President Elect—Lloyd Alexander Ky. State
V. President—Karl Hussung Murray St. Univ.
Secretary—Robert Larance Eastern Ky. Univ.
Treasurer—C. B. Hamann Asbury College
AAAS Representative—Mary Wharton (2 yr.) Georgetown
Board of Directors (1972)
Gordon Wilson Western Ky. Univ.
L. A. Krumholz Univ. of Louisville

With no nominations from the floor, these were elected by acclamation.

Dr. Mary Wharton, AAAS Representative, reported to the Academy that the AAAS at last year's meeting adopted the following resolution:

> *Whereas* a unique natural area of geological, botanical and zoological significance, valuable in research and instruction as well as providing rare scenic beauty, would be destroyed by the construction of the Red River Dam in Kentucky; and
>
> *Whereas* man, though able to build laboratories, can never recreate a natural area that has been annihilated; and
>
> *Whereas* alternative means of flood control and water storage may be found; and
>
> *Whereas* the dam was authorized and funds were appropriated without adequate consideration of the intangible value of the area to be lost; therefore
>
> *Be it resolved* that the Council of the American Association for the Advancement of Science appeal to the President of the United States to direct the Water Resources Council to study the advisability of the Red River Dam in Kentucky and to delay construction until a more thorough study can be made; and
>
> *Be it further resolved* that copies of this resolution be sent to the President of the United States; to the Director, Bureau of the Budget; the Secretary of the Army; Secretary of Agriculture; Secretary of the Interior; and the Governor of the Commonwealth of Kentucky.

A vote of thanks from the KAS was given Dr. Wharton for her devoted service to the Academy.

With no further business, the president declared the meeting adjourned at 12:45 P.M.

Robert Larence
Secretary

OFFICERS OF THE ACADEMY

President .... Paul G. Sears, University of Kentucky
President-Elect .... Orville Richardson, Kentucky Wesleyan College
Vice-President .... L. A. Krumholz, University of Louisville
Secretary .... Robert S. Larance, Eastern Kentucky University
Treasurer .... C. B. Hamann, Asbury College
Representative to
A.A.A.S. Council .... Mary Wharton, Georgetown College
Director, Junior Academy .... Morris D. Taylor, Eastern Kentucky University
Editor of the Transactions .... Raymond E. Hampton, University of Kentucky

BOARD OF DIRECTORS

John M. Carpenter .... to 1971
William M. Clay .... to 1971
Karl F. Hussung .... to 1970

Grace Quinto .... to 1970
Lloyd E. Alexander .... to 1969
Margaret B. Heaslip .... to 1969
William B. Owsley .... to 1968
Alfred M. Wolfson .... to 1968

PROGRAM

Friday, November First

Friday, November First

4:00 p.m. Registration, Coffee Hour, and Exhibits

6:00 p.m. Banquet

Grand Ball Room, Paul L. Garrett Student Center

Welcome: Dr. Raymond L. Cravens
Vice-President for Academic Affairs and
Dean of the Faculties

After Dinner Speaker: Dr. G. W. Stokes
Director of the Institute of Tobacco and Health
Research, University of Kentucky

Topic: Tobacco and Health Research

9:00 p.m. Social Hour

Kentucky Room, Holiday Inn Motel

Saturday, November Second

8:15 a.m Sectional Meetings

11:45 a.m. Annual Business Meeting

1:00 p.m. Luncheon
Faculty Dining Hall,
Paul L. Garrett Student Center

Speaker: Dr. Henry F. Dobyns
Chairman, Department of Anthropology, University of Kentucky

Topic: An Anthropological View on the Military Coup in
Latin America

ANTHROPOLOGY SECTION

Henry F. Dobyns, Chairman
Louise M. Robbins, Secretary

History of Anthropology at Bellarmine-Ursuline College. Prof. Joel, Bellarmine-Ursuline College.

Berea Looks At Anthropology. Prof. Stermer, Berea College.

Manifest and Latent Functions of Knife Trading in an Eastern Kentucky Neighborhood. Steve Cain, University of Kentucky.

Anthropology at Western Kentucky University—Past, Progress, and Future Prospects. Harold Hepler and Clifton Bryant, Western Kentucky University.

The Yap Empire: Its Confirmation and Disintegration. Bob Potter, University of Kentucky

Election of Officers.

BOTANY AND MICROBIOLOGY SECTION

Harold E. Eversmeyer, Chairman
Charles J. Isbell, Secretary

Election of Officers

Population Differences in Germination of *Liquidambar styraciflua* L. Joe E. Winstead, Western Kentucky University.

Acid Phosphatase Activity in Tobacco Mosaic Virus Susceptible and Hypersensitive Varieties of Burley Tobacco. David J. Saxon and David Brumagen, Morehead State University.

An Evaluation of the Importance of Schizokinens During Cell Proliferation in Mass Culture. Robert E. Daniel, Sarah E. Plummer, R. G. Barlow, and W. E. West, Murray State University.

Selected Color Slides of the Flora of the Red River Gorge Area. Robert S. Larance, Eastern Kentucky University.

Micrococcaseae Isolated from the Intestinal Tract of Starlings. D. R. Witty and L. P. Elliott, Western Kentucky University.

Comparison of Chemical Components of *Burcella abortus* Cell Walls, an Avirulent Strain 19 A and a Virulent Strain 230 gamma. George Kellerman, Catherine Spalding College.

Enzymatic Lysis of Fungal Walls. Roy A. Barrett, Kentucky State College.

Cause of Common Market Disease of Lettuce. William E. Palmore and L. P. Elliott, Western Kentucky University.

Field Work in Tropical Cloud Forests of Panama. Sister M. Victoria Hayden, Catherine Spalding College.

CHEMISTRY SECTION

B. E. McClellan, Chairman
K. Grant Taylor, Secretary

Chlorination of Acetophenone with Cupric Chloride. W. G. Lloyd and J. G. Anderson, Western Kentucky University.

Solvent Extraction Studies of Transition Metals with High Molecular Weight Amines. B. E. McClellan and *R. H. Parmelee, Jr.,* Murray State University.

Phototoxic Principles of *Lananthesis tinctoria ellis.* H. O. Klingele, Department of Pharmachology, University of Louisville.

Synthesis and Electron Impact Studies on Thenylazoquinolines. E. V. Brown, University of Kentucky.

High Resolution Mass Spectrometry of Selected Methyl Acetylacetonates. *R. E. Fraas,* G. L. Chaney, and R. W. Kiser, University of Kentucky.

Negative ion Mass Spectra of Substituted Methyl Carbonyls. R. E. Sullivan and R. W. Kiser, University of Kentucky.

Coffee Break and Election of Officers.

Magnetic Susceptibilities of Yttrium Hydrides. *C. D. Parks* and W. G. Bos, University of Louisville.

Nuclear Magnetic Reasonance Studies of Purines. *J. L. Wong* and R. Simpson, University of Louisville.

Carboneoids with Neighboring Heteroatoms. *K. G. Taylor* and W. E. Hobbs, University of Louisville.

Separation of 2,-4-Dinitrophenylhydrazones into Classes by Thin Layer Chromotography. *C. S. Beyer, Jr.* and T. E. Kargle, Bellarmine-Ursuline College.

GEOLOGY-GEOGRAPHY SECTION

Denis Spetz, Chairman
W. R. Jillson, Secretary

Election of Officers

Snail Genus *Sinuitina* in the United States and Australis and Its Evolutionary Trends. James E. Conkin, University of Louisville, and Barbara M. Conkin, Jefferson Community College.

Early Pleistocene Glaciation in Northeastern Kentucky and Its Ponded Outfall at Levee in Montgomery County. Willard Rouse Jillson, Former State Geologist, Frankfort, Kentucky.

Extension of the Lost River Chert into Kentucky. Preston McGrain, Assistant State Geologist, Lexington, Kentucky.

PHYSICS SECTION

Ted M. George, Chairman
George K. Miner, Secretary

An Experiment Library. Robert E. Dawson, Western Kentucky University.

Fringe Synthesis Radio Interferometry. M. V. Robinson, Western Kentucky University.

Jupiter Emission Recorded During the 1968 Apparition. R. L. Scott and N. F. Six, Western Kentucky University.

A Broadband Radio Telescope for the Study of Solar System Emissions. J. D. Burd, M. V. Robinson, and N. F. Six, Western Kentucky University.

A Neutron Time-of-Flight Spectrometer. D. K. Moorman and D. L. Humphrey, Western Kentucky University.

A Low-Energy Electron Reflection Spectrometer. A. D. Sanders, J. D. Burd, and M. W. Russell, Western Kentucky University.

The Application of Fixed and Rotating Vectors to Electric Circuits. Manuel Schwartz, University of Louisville.

Time Reversal Invariance and Properties of Laser Light. Joel A. Gwinn, University of Louisville.

Positron Annihilation in Al and Mg. L. Burton, J. Davis, and W. E. Huang, University of Louisville.

Strong Relativistic Effects of Slow Charged Particles. John F. Davis, University of Louisville.

Some Calculations Concerning the Energy Straggling of Heavy Charged Particles. J. Cook, R. Smith, and M. G. Payne, Berea College.

The Effect of Irregularities in Thickness on the Energy Straggling of Alpha Particles in This Foils. R. Thorpe, J. Cochran, and M. G. Payne, Berea College.

Magnetic Anisotropy of Acenaphthene. Richard Rolfes and Sr. Mary Eleanor Fox, Thomas Moore College.

An Ultrasensitive Potentiometer at Helium Temperatures. William H. Rauckhorst, Bellarmine-Ursuline College.

Overhead Transparencies in the Physics Classroom. William C. Simpson, Morehead State University.

Some Interesting Ideas for Lecture and Laboratory. J. G. Black, Eastern Kentucky University.

GPLOT, a Generalized Computer Plotting Program. Marcus Lossner; Murray State University.

A Numerical Analysis of Delayed Coincidence Data by Laplace Transform Methods. Joyce M. Evans, Greg Parrish, and Lynn Bridwell, Murray State University.

Another Multiparameter Data Acquisition System, CIMDA. L. M. Beyer and Lynn Bridwell, Murray State University.

PSYCHOLOGY SECTION

Joseph H. Voor, Chairman
Richard Griffith, Secretary

Intimacy and Behavior Change in Large Groups: A Model. Voro A. Clark, Murray State University.

Repression-Sensitization and Verbal Conditioning. Leon Siber, Comprehensive Care Center, Madisonville, Kentucky.

A Learning Channels Theory Applied to the Analysis of Serial Learning. Harry S. Tausch, Psychology Department, Western Kentucky University.

A Method and Technique of Teaching Large Classes of General Psychology in College. A. W. Laird, Psychology Department, Western Kentucky University.

Cultural Effects of Subjects and Experimenter Interaction Effects in Perpetual Defense. Edward S. Rosenbluh, Patrick Schmitt, and Richard Hutshison, Department of Psychology, Bellarmine-Ursuline College.

Concept Identification as a Function of Experimenter Sex, Subject Sex, and Experimenter Enthusiasm or Boredom. Edward S. Rosenbluh, Joseph W. Schmidt, Department of Psychology, Bellarmine-Ursuline College.

Grades, Attendance, and Extrace and Extraversion. Else Dotson and Donald Templer, Western Kentucky University.

Election of Officers.

Undergraduate Programs in Psychology in Non-Public Institutions:
Psychology Program at Georgetown
Psychology Program at Centre
Psychology Program at Bellarmine-Ursuline

SCIENCE EDUCATION SECTION

Wendell Cave, Chairman
Frank Howard, Secretary

Election of Officers.

One Approach to the Dissemination of Innovations in Science Teaching. R. K. Atwood, University of Kentucky.

A Summer School Project for Academically Unsuccessful High School Students. T. D. Johnsten, Eastern Kentucky University.

Comic Strip Teaching Aids. W. C. Simpson, Morehead State University.

ZOOLOGY SECTION

Branley A. Branson, Chairman
Donald L. Batch, Secretary

Election of Officers.

A Microsporidian Parasite of the Slug, *Limax maximus*. John D. Parker, Western Kentucky University.

The Diet of *Sturnus vulgaris* in Warren County, Kentucky. H. E. Shadowen, Western Kentucky University.

A Differential Strain for Invertebrate Neurosecretory Cells. Robert W. Hackney, Murray State University.

An X[1]/Ray Induced Translocation in *Drosophila melanogaster*. Gertrude C. Ridgel, Kentucky State College.

The Effects of Oxytocin on Water Retention in Two Plethodontid Salamanders. H. L. Scurry and E. C. Crawford, Jr., University of Kentucky.

The Relationship Between Cutaneous Gas Exchange and Pulmonary Gas Composition in *Sauromalus obesis*. R. R. Schultetus and E. C. Crawford, Jr., University of Kentucky.

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