TRANSACTIONS

of the

Tennessee Academy of Science

VOLUME ONE

April, 1912, to December, 1913

Issued August 1, 1914, Nashville, Tenn.

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Williams Printing Company, Nashville

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History of the Organization

To Dr. George H. Ashley, who became State Geologist in 1910, the Tennessee Academy of Science probably owes its existence. Soon after his arrival in the State, Dr. Ashley suggested such an organization, and the matter was taken up by him with members of the faculties of several educational institutions and with other men interested in scientific work. The suggestion met with ready response, and Professor C. H. Gordon, of the University of Tennessee, took the initiative in preparing a call and securing the signatures of several of the members of the faculty of the University of Tennessee. Other names representing Vanderbilt University and the State Geological Survey were soon added to the call and the letter was sent to about one hundred persons engaged in or interested in scientific work in the State.

The original call prepared by Prof. Gordon was dated February 5, 1912, and was signed by C. H. Gordon, Samuel M. Bain, Maurice Mulvania, Asa A. Schaeffer, Ernest Shaw Reynolds, E. C. Cotton, J. A. Switzer, Chas. A. Perkins, H. A. Morgan, Chas. O. Hill, J. T. Porter, L. C. Glenn, J. T. McGill, John Daniel and Geo. W. Martin.

On March 4, 1912, the letter was duplicated and sent to interested persons, the following additional signatures being affixed: Geo. H. Ashley, A. H. Purdue and W. A. Nelson.

Following is a copy of the original call for the organization of the Academy:

"Nashville, Tenn., March 4, 1912.

"Dear Sir—Believing there is urgent need of a closer association of those interested in the study of the sciences and related branches in the State of Tennessee, and that the time is ripe for an organization that will promote these interests, the undersigned ask your coöperation in the establishment of a State Academy of Science.

"The field to be occupied by this organization will correspond to that of similar organizations now in successful operation in other States. It is proposed to meet annually for the reading and discussion of papers related to scientific work or achievements of the members and for the furtherance of the scientific interests of the State of which, in its corporate capacity, the Academy will stand as the representative.

"The general advance in education, the establishment of the State Geological Survey and the splendid achievements of the workers in the field of agricultural education, all point to this as a propitious time for the establishment of an institution which shall have for its object the interchange of ideas and the coördination of the various scientific interests of Tennessee.

"It is proposed to have a meeting of those interested at the office of the State Geologist in Nashville on March 9, 1912, for the purpose of forming such an institution as herein proposed. You are cordially and urgently invited to attend and contribute by your presence and advice to the success of the undertaking. Please fill out and mail at once the inclosed card indicating whether we may count on your support in this movement. Very truly yours,"

(Signed)

GEO. H. ASHLEY, Geological Survey.
A. H. PURDUE, Geological Survey.
W. A. NELSON, Geological Survey.
L. C. GLENN, Geology, Vanderbilt University.
J. T. MCGILL, Vanderbilt University.
JOHN DANIEL, Physics, Vanderbilt University.
GEO. W. MARTIN, Biology, Vanderbilt University.
CHAS. A. PERKINS, University of Tennessee.
CHAS. O. HILL, University of Tennessee.
C. H. GORDON, Geology, University of Tennessee.
S. M. BAIN, Botany, University of Tennessee.
MAURICE MULVANIA, Bacteriology, University of Tennessee.
ASA A. SCHAEFFER, University of Tennessee.
E. S. REYNOLDS, Botany, University of Tennessee.
E. C. COTTON, University of Tennessee.
J. A. SWITZER, C. E., University of Tennessee.
H. A. MORGAN, Exp. Sta., University of Tennessee.
J. T. PORTER, Physics, University of Tennessee.

The result of this letter was the formation of the Tennessee Academy of Science, on Saturday, March 9, 1912, in the Hall of Representatives at the State Capitol, by a representative gathering of persons, among whom were the following: Mrs. C. L. Fraley, Nashville High School; L. C. Glenn, Vanderbilt University; Watson Selvage, University of the South; Colin M. Mackall, University of the South; James A. Lyon, Southwestern Presbyterian University; A. H. Purdue, State Geologist elect; P. H. Manning, Nashville; E. J. McCroskey, Lebanon; V. L. Minehart, Cumberland University; L. Junius Desha, Chemist, Tennessee Food Inspection Bureau; Geo. H. Ashley, State Geologist; C. H. Gordon, University of Tennessee; Wilbur A. Nelson, Assistant State Geologist.

At this meeting, March 9, 1912, Dr. Geo. H. Ashley presided. A committee, consisting of Prof. C. H. Gordon, Dr. Geo. H. Ashley and Wilbur A. Nelson, was appointed to draw up a constitution and by-laws. The committee reported at the afternoon session and the constitution and by-laws were adopted.

Wilbur A. Nelson was appointed temporary secretary and treasurer. A committee, composed of Doctors L. C. Glenn and L. Junius Desha and the Secretary, was appointed to make arrangements for a continuance of the meeting on April 6, 1912, for the election of officers and the transaction of other business.

The first general meeting of the Academy was accordingly held on April 6, 1912, in the hall of the Carnegie Library of Nashville, at which time the following officers were elected:

President, C. H. Gordon, University of Tennessee, Knoxville.
Vice-President, J. I. D. Hinds, Cumberland University, Lebanon.
Secretary, Wilbur A. Nelson, State Geological Survey, Nashville.
Treasurer, S. M. Barton, University of the South, Sewanee.
Editor, E. S. Reynolds, University of Tennessee, Knoxville.

The Executive Committee (which consists of the officers and two additional members appointed by the President) was completed by the appointment of Prof. A. W. Prince, Union University, Jackson, and Dr. L. C. Glenn, Vanderbilt University, Nashville.

The complete organization of the Tennessee Academy of Science was thus consummated on April 6, 1912.

Constitution

ARTICLE I—NAME AND OBJECTS.

SECTION 1. This Association shall be called the Tennessee Academy of Science.

SEC. 2. The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science; to promote intercourse between persons engaged in scientific work, especially in Tennessee; to assist by investigation and discussion in developing and making known the material, educational and other resources and riches of the State; to arrange and prepare for publication such reports of investigations and discussions as may further the aims and objects of the Academy as set forth in these articles.

ARTICLE II—MEMBERSHIP.

SECTION 1. The membership of the Academy shall consist of active, associate and honorary members.

SEC. 2. *Active Members*—Any white person interested or engaged in any department of scientific work or original research in any department of science shall be eligible to active membership in the Academy. Active members only shall have the right to vote and to hold office.

SEC. 3. *Associate Members*—Any white undergraduate college student, who is interested in any department of scientific work, may become an associate member; also any active member on removing from the state may, on his request, be transferred to this associate membership class.

SEC. 4. *Honorary Membership*—Any white person who has attained prominence in any department of science, on the recommendation of the Executive Committee, may be elected an honorary member at any regular meeting by a three-fourths vote of the active members present. No more than three honorary members shall be elected in any year.

SEC. 5. *Method of Election**—To become an active or associate member, it shall be necessary, first, that the candidate make application in writing, signed by two active or honorary members; second, that such application be approved by the Executive Committee; third, that he receive a majority vote of the active members present at any regular meeting, and fourth, that he pay the annual dues for the first year.

ARTICLE III.

SECTION 1. *Officers*—The officers of the Academy shall consist of a President, Vice-President, Secretary, Treasurer, and Editor, who shall be elected by ballot at the annual meeting and shall hold office one year, or until their successors are installed. They shall perform the duties usually pertaining to their respective offices.

SEC. 2. The Executive Committee shall consist of the officers of the Academy, together with two other members, who shall be appointed by the President. It shall be the duty of the Executive Committee to approve or reject candidates for election as members, to prepare the programs and have charge of the arrangements for all meetings.

ARTICLE IV—PUBLICATIONS.

The official publication of the Academy shall be called the *Transactions of the Tennessee Academy of Science,* and shall be published as occasion demands.

The Executive Committee shall have authority to make arrangement for the publication of a journal, provided that no more than one-half of the annual dues be used for that purpose.

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*Amended, November 28, 1913, to read as follows: "To become an active or associate member, it shall be necessary, first, that the candidate make application in writing, indorsed by two active or honorary members; second, that he receive a majority vote of the Executive Committee; and third, that he pay the annual dues for the first year."

ARTICLE V—MEETINGS.

The annual meetings shall be held on the Friday following Thanksgiving Day, at such place as the Executive Committee shall determine. Special meetings may be held at such times and places as the Executive Committee shall determine.

ARTICLE VI—DUES.

The annual dues of the active members shall be $3.00 and of associate members $2.00, which shall entitle them to receive the Transactions and other publications of the Academy. Honorary members shall not be required to pay dues, but any honorary member desiring to receive the publications of the Academy shall pay $2.00 per annum.

ARTICLE VII—AMENDMENTS.

This constitution may be altered or amended at any annual meeting by a three-fourths majority of the members attending, due notice of such change having been given fifteen days in advance.

By-Laws

1. On motion, any special department of science shall be assigned to a curator, whose duty it shall be, with the assistance of the other members interested in the same department, to endeavor to advance knowledge in that particular department. Each curator shall report at such time and place as the Academy shall direct. These reports shall include a brief summary of the progress of the department during the year preceding the presentation of the report.

2. The retiring President shall deliver a public address on the Friday evening of the annual meeting.

3. The Editor shall attend to the securing of proper newspaper reports of the meetings, assist the Secretary and edit all publications of the Academy.

4. No meeting of the Academy shall be held without a notice of the same having been sent to the address of each member at least fifteen days before such meeting.

5. No bill against the Academy shall be paid without an order signed by the President and countersigned by the Secretary.

6. Members who shall allow their dues to remain unpaid for two years, having been annually notified of their arrearages by the Treasurer, shall have their names stricken from the roll.

7. Twelve members shall constitute a quorum for the transaction of business.

Officers for Each Year

The officers of the Tennessee Academy of Science are elected at each regular annual meeting of the Academy, which is held on the Friday following Thanksgiving Day. They shall hold office for one year, or until their successors are installed.

The first general meeting was held April 6, 1912, and the officers elected were as follows:

President, Chas. H. Gordon, University of Tennessee, Knoxville.
Vice-President, J. I. D. Hinds, Cumberland University, Lebanon.
Secretary, Wilbur A. Nelson, State Geological Survey, Nashville.
Treasurer, Samuel M. Barton, University of the South, Sewanee.
Editor, E. S. Reynolds, University of Tennessee, Knoxville.

At the second election, November 30, 1912, the following were chosen:

President, Watson Selvage, University of the South, Sewanee.
Vice-President, G. W. Dyer, Vanderbilt University, Nashville.
Secretary, Wilbur A. Nelson, State Geological Survey, Nashville.
Treasurer, Samuel M. Barton, University of the South, Sewanee.
Editor, R. M. Ogden, University of Tennessee, Knoxville.

At the third election, November 28, 1913, the following were chosen:

President, L. C. Glenn, Vanderbilt University, Nashville.
Vice-President, W. E. Myer, Carthage.
Secretary, Roscoe Nunn, U. S. Weather Bureau, Nashville.
Treasurer, A. Belcher, Middle Tennessee State Normal School, Murfreesboro.
Editor, Jas. A. Lyon, Southwestern Presbyterian University, Clarksville.

Members

(*The list includes all those elected prior to June* 1, 1914.)

Ashley, Geo. H-------U. S. Geological Survey, Washington, D. C.
Ayres, Brown--------University of Tennessee, Knoxville.

Bain, S. M----------University of Tennessee, Knoxville.
*Balcom, R. W-------Custom House, Nashville.
Barton, Samuel M----University of the South, Sewanee.
Belcher, A-----------Middle Tennessee State Normal School, Murfreesboro.
Bentley, G. M-------University of Tennessee, Knoxville.
Blake, V. W---------Hume-Fogg High School, Nashville.
Bowers, Paul C------9 Garland Avenue, Nashville.
Bowrom, Wm. M----The Tradesman, Chattanooga.
Brown, Lucius P-----State Food and Drug Inspection Bureau, Nashville.
Buchanan, H. E------University of Tennessee, Knoxville.
Butler, John S-------U. S. Engineer Office, Nashville.

Cisco, J. G----------Nashville, Tenn.
Cole, W. R----------Napier Iron Works, Nashville.
Cotton, E. C---------University of Tennessee, Knoxville.
Cude, Harold E------Vanderbilt University, Nashville.

Daniel, John --------Vanderbilt University, Nashville.
Desha, L. J----------University of Tennessee, Memphis.
Dudley, Wm. L------Vanderbilt University, Nashville.
Dyer, G. W---------Vanderbilt University, Nashville.

Essary, S. H---------University of Tennessee, Knoxville.

Fraley, Mrs. C. L----Hume-Fogg High School, Nashville.

*Gill, Miss L. Drake---Sewanee.
Glenn, L. C----------Vanderbilt University, Nashville.
Gordon, C. H--------University of Tennessee, Knoxville.

* Resigned.

Gorrell, G. W---------University of Chattanooga, Chattanooga.
*Grab, E. G-----------Custom House, Nashville.

Hall, Wm. B---------University of the South, Sewanee.
Hinds, J. I. D--------Cumberland University, Lebanon.
Hollinshead, W. H---Vanderbilt University, Nashville.
Holt, R. B-----------Tennessee College for Young Ladies, Murfreesboro.
Holtzendorff, P. W---418 Memphis Trust Building, Memphis.
Howser, W. D---------State Game Warden, Nashville.

Igams, C. B----------West Tennessee State Normal School, Memphis.
Isbell, J. E-----------Madison.

Johnson, Julius A----216 East Chester Street, Jackson.

Kaserman, Emile ----Jefferson City.
King, Miss J. M------Middle Tennessee State Normal School, Murfreesboro.

Lee, Victor P--------Vanderbilt University, Nashville.
Lewis, Henry W-----311 Sixth Avenue, North, Nashville.
Luck, J. J------------Vanderbilt University, Nashville.
Lyon, Jas. A----------Southwestern Presbyterian University, Clarksville.

McClure, James -----Vanderbilt University, Nashville.
McCroskey, E. J-----Lebanon.
McGill, J. T----------Vanderbilt University, Nashville.
McKnight, E. B------569 North Main Street, Jackson.
*Mackall, C. M-------University of the South, Sewanee.
Manning, P. H------West Tennessee State Normal School, Memphis.
Maynard, T. P-------321 James Building, Chattanooga.
Minehart, V. L-------2070 Rosedale Avenue, Oakland, Cal.
Myer, W. E----------Carthage.
Morgan, H. A--------University of Tennessee, Knoxville.
Mulvania, Maurice ---University of Tennessee, Knoxville.

Neel, L. R-----------Southern Agriculturist, Nashville.
Nelson, Wilbur A----Geological Survey, Nashville.
Nunn, Roscoe -------U. S. Weather Bureau, Nashville.

Ogden, R. M---------University of Tennessee, Knoxville.

* Resigned.

Ott, W. P.............Vanderbilt University, Nashville.

Paris, John T.........181 Second Avenue, North, Nashville.
Perkins, Chas. A......University of Tennessee, Knoxville.
Peterson, Verd ......Middle Tennessee State Normal School, Murfreesboro.

Porter, Miss Alice N..University of Tennessee, Knoxville.
Porter, Jas. T........University of Tennessee, Knoxville.
Prince, A. W..........Union University, Jackson.
Purdue, A. H..........State Geological Survey, Nashville.

Raymond, Reginald I..University of the South, Sewanee.
*Reynolds, E. S.......Agricultural College, North Dakota.
Rose, H. W............Lincoln Memorial University, Cumberland Gap.

Sample, J. W..........Tennessee Department of Agriculture, Nashville.

Schaeffer, Asa A......University of Tennessee, Knoxville.
Selvage, Watson.......University of the South, Sewanee.
Spitz, Herman ....215 Eve Building, Nashville.
*Switzer, J. A........University of Tennessee, Knoxville.
Sylvester, Geo. E.....State Bureau of Mines, Rockwood.

Thomas, B. F..........808 Pine Street, Chattanooga.
Thompson, Thos. D....Brown Laboratories, Nashville.

Voorhees, J. F........U. S. Weather Bureau, Knoxville.

Wade, Bruce ....Vanderbilt University, Nashville.
Walker, Robert S......Southern Fruit Grower, Chattanooga.
White, Geo. R.........State Veterinarian, Nashville.
Williamson, C. S......Tulane University, New Orleans, La.
Wilson, A. J..........403 McCallie Ave., Chattanooga.
Willson, C. A.........University of Tennessee, Knoxville.
Wilson, Latimer J....1405 Gartland Avenue, Nashville.
*Wood, A. E...........Vanderbilt University, Nashville.

Yoe, John H...........Vanderbilt University, Nashville.

* Resigned.

Record

(From the organization of the Academy to the end of year 1913.)

MEETING OF APRIL 6, 1912.

This was the first general meeting of the Academy. The meeting was held in the hall of the Carnegie Library of Nashville, at 10 a. m. The first business was the election of permanent officers, which resulted as stated on page 7.

Prof. A. A. Schaeffer spoke in regard to a journal of science which he proposed to establish, explaining the style and purposes of the proposed publication.

It was decided to hold the next meeting at Knoxville, on the Friday after Thanksgiving Day, which would be November 29.

After the reading and discussion of several papers, adjournment was taken at noon for luncheon, most of the members going in a body to the Maxwell House.

At 2 p. m. the meeting reassembled and the program was continued, ten minutes for discussion being allowed after each paper was read.

The program of papers was as follows:

On the Reported Discovery of Radium in Arkansas,
A. H. PURDUE, former State Geologist of Arkansas.

Neon and Wireless Waves,
WM. L. DUDLEY, Vanderbilt University.

Rock Striations and Their Causes,
CHAS. H. GORDON, University of Tennessee.

Railroads and Railroad Building in Tennessee Before the Civil War,
G. W. DYER, Vanderbilt University.

The Beginnings of Music,
R. M. OGDEN, University of Tennessee.

Food and Drug Inspection in Tennessee,
LUCIUS P. BROWN, State Bureau of Food and Drug Inspection.

Review of History of Geological Work in Tennessee,
L. C. GLENN, Vanderbilt University.

Some Remarkable Phenomena of the Tornado in Montgomery County, Tennessee, April 29, 1909,
JAS. A. LYON, Southwestern Presbyterian University.

Some Effects of Parasitic Fungi on Leaf Tissue,
ERNEST S. REYNOLDS, University of Tennessee.

(*a*) Photomicography in Colors by Lumiere Process (illustrated),
(*b*) Apparatus for Washing Fixed Microscopic Material (illustrated),
S. M. BAIN, University of Tennessee.

The Selection of Food Among Lower Animals (illustrated),
ASA A. SCHAEFFER, University of Tennessee.

Voltaic Action in Combination Teeth Fillings,
JOHN DANIEL, Vanderbilt University.

EVENTS DURING THE YEAR 1912.

The Secretary sent an account of the meeting of April 6 to *Science* and it was published in the issue of May 17, 1912, pages 794 and 795.

In September, Prof. E. S. Reynolds resigned as Editor, on account of his leaving the State. Prof. A. A. Schaeffer was appointed by the Executive Committee to fill the vacancy.

Printed announcements of the November meeting were sent to all the members, accompanied by a printed form for abstracts of any papers that might be desired to be read at the meeting. The announcement stated that the meeting would be held at the University of Tennessee, Knoxville, on Friday, November 29, 1912, beginning at 10 a. m. Members desiring to present papers were urged to forward titles and abstracts to the Secretary, in order that the program might be arranged.

Four hundred copies of the program for the November meeting were printed. These were sent to the members and to the principal newspapers in the State.

The Secretary recorded that "the members of the Academy numbered 74 on November 25, 1912, 70 of whom are active members and 4 associate members."

MEETING OF NOVEMBER 29-30, 1912.

The meeting was held at Carnegie Hall, University of Tennessee, Knoxville, beginning at 10 a. m., November 29.

In addition to the program of papers and discussions, the following matters were considered:

A resolution was adopted, recommending to the Governor and the Legislature of Tennessee the immediate passage of a law authorizing the Governor to appoint a Conservation Commission which shall have power (1) to grant, under such restrictions as are hereinafter suggested, renewable franchises for a limited term to all corporations desiring to make use of said water power; (2) to secure a permanent water supply, to provide for all coöperation of the State in forestry conservation, and the eventual creation of a State Forest Reserve; (3) to prevent the diversion of electric power derived from the natural waters of Tennessee, to the enrichment of other States, and to encourage its utilization within our own borders, and to that end, (4) to coöperate with the boards of trade and other civic bodies to secure the location of industrial plants in all localities where power is cheap and abundant; (5) to secure a more permanent and lasting supply of cheap power throughout this State, in all parts thereof, whether blessed with water power or not, by the prevention of waste in mining and use of coal.

It was further recommended that this Commission be instructed to investigate the feasibility of a State-wide system of power conservation development and transmission, whereby every section of the State might enjoy an equitable share of the benefits thereof, and that it report such investigation and the finding of the Commission to the next session of the Legislature.

Another resolution was passed urging the Legislature to take immediate action to provide an exhibit that shall properly and adequately set forth the resources of the State, especially in her water power, her agricultural resources, her forests, her mineral wealth and her manufacturing advantages; and it was suggested that such an exhibit could be used successively at the National Conservation Exposition at Knoxville in 1913, the National Exposition at San Diego in 1914, and the Panama-Pacific Exposition at San Francisco in 1915.

At a meeting of the Executive Committee on November 29, action was taken fixing the dues for the period April 6, 1912, to December 31, 1912, at $2.25 instead of the regular annual dues of $3.00. The committee at this time also defined the relations of the Academy to the "Science Record."

The election of officers was held on November 30, 1912, with the following result:—President, Watson Selvage, University of the South; Vice-President, G. W. Dyer, Vanderbilt University; Secretary, Wilbur A. Nelson, Tennessee Geological Survey, Nashville; Treasurer, Samuel M. Barton, University of the South; Editor, R. M. Ogden, University of Tennesssee.

The program of papers presented at this meeting was as follows:

The Taste Sense in Frogs,
ALICE N. PORTER, University of Tennessee.

Hydrogen Peroxide as a Bleaching Agent for Entire Insects,
E. C. COTTEN, University of Tennessee.

Relation of the State to Its Water Power Resources,
J. A. SWITZER, University of Tennessee.

The Recent Disturbance in the Northern Equatorial Belt of Jupiter (read by Professor Porter),
LATIMER J. WILSON, Nashville.

The Effects of a Soy Bean Crop on a Following Cereal,
MAURICE MULVANIA, University of Tennessee.

The Fourth Dimension,
SAMUEL M. BARTON, University of the South.

The Occurrence of Aerial Roots on the Virginia Creeper,
SAMUEL M. BAIN, University of Tennessee.

Micro-Color Photography,
SAMUEL M. BAIN, University of Tennessee.

Science and Progress in the South (address by the retiring President),
C. H. GORDON, University of Tennessee.

The Mastadon and the Glacial Age (illustrated),
W. E. MYER, Carthage.

Diffraction Phenomena Due to the Dimensions of the Source of Light,
BROWN AYRES, University of Tennessee.

Contributions on the Feeding Habits of Ameba,
ASA A. SCHAEFFER, University of Tennessee.

The Green Slates of Georgia,
T. POOLE MAYNARD, Chattanooga.

The Importance of the Study of Meteorology in Its Relations to Agriculture,
J. F. VOORHEES, U. S. Weather Bureau, Knoxville.

The Breaking of the Nashville Reservoir, November 5, 1912 (illustrated),
WILBUR A. NELSON, State Geological Survey, Nashville.

Types of Iron Ore Deposit in East Tennessee,
C. H. GORDON, University of Tennessee.

EVENTS DURING THE YEAR 1913.

The Secretary, Mr. Wilbur A. Nelson, on account of his leaving the State, offered his resignation in June, but no action was taken, and he remained in office until his departure in September.

MEETING OF NOVEMBER 28, 1913.

The meeting was held in Furman Hall, Vanderbilt University, opening at 11 a. m., with an address by the President.

In the absence of the Secretary, the President appointed Mr. Victor P. Lee, Temporary Secretary.

During the morning session the following papers were presented. Discussion followed each paper.

A Natural Bridge of Tennessee in Process of Formation,
H. D. MISER, U. S. Geological Survey.

Development of Phosphate Industry in Tennessee,
LUCIUS P. BROWN, State Bureau of Food and Drug Inspection.

An Unnoticed Physiographic Feature of Tennessee,
L. C. GLENN, Vanderbilt University.

Adjournment for luncheon occurred at 12:30 p. m. The meeting assembled for the afternoon session at 2:30 p. m., and the following papers were presented and discussed:

Caverns and Rock Shelters of the Cumberland Valley (illustrated),
W. E. MYER, Carthage.

Food Preservatives,
L. C. BLISS, State Bureau of Food and Drug Inspection.

A New Geological Map of Tennessee,
A. H. PURDUE, State Geological Survey.

Some Neglected Principles of Physiography,
A. H. PURDUE, State Geological Survey.

Some Early Geologic Maps of Tennessee,
L. C. GLENN, Vanderbilt University.

Other matters coming before this meeting were, in brief, as follows:

The Committee on Resolutions made a partial report, but was, on motion, ordered continued, with the understanding that a full report would be rendered at the next annual meeting. There was considerable discussion relative to the nature of resolutions that should be presented. The discussion was engaged in by Messrs. Myer, Purdue, Barton, and Brown.

Officers were elected for the ensuing year as follows:

President, L. C. Glenn; Vice-President, W. E. Myer; Secretary, Roscoe Nunn; Treasurer, A. Belcher; Editor, Jas. A. Lyon.

The Treasurer read his report, which was received.

The connection of the Academy with "Science Record" was discussed and it was finally decided that all connection with "Science Record" should terminate with the present year. The matter of future publication of the Transactions of the Academy received considerable attention. On motion, the Executive Committee was given full power to take such steps as they may think wise to provide for the publication of the papers and other literature of interest to the members.

The method of electing members (Article II, Section 5, of the Constitution) was changed. By the amendment, the Executive Committee is given power to elect new members.

The newly elected President appointed the following members of the Executive Committee, in accordance with Constitution: Prof. S. M. Bain and Mr. E. J. McCroskey.

Treasurer's Reports

SEWANEE, TENN., November 27, 1912.

To the President of the Tennessee Academy of Science:

DEAR SIR—As Treasurer of the Academy since April 6, 1912, I beg leave to make the following report of receipts and expenditures up to November 27, 1912:

RECEIPTS.

Dues of active members for 1912	$144 00
Dues of active members for 1913	3 00
Dues of associate members for 1912	8 00
Total receipts to date	$155 00

EXPENDITURES.

To W. A. Nelson, expenses of first meeting in March	$ 14 74
To State Geological Survey, for notices	1 75
To W. A. Nelson, for hall expenses, meeting April 6	2 00
April 15, Foster & Parkes Co., letterheads and envelopes	9 75
June 17, University Supply Store, for ledger	1 75
June 17, Postage for Treasurer	3 00
June 26, W. A. Nelson, for printing cards	1 25

November 6, Foster & Parkes Co., printing circulars	14 75
Nov. 29, President Gordon, for programs, stamps, etc	10 86
Total expenses to date	$ 59 85
Balance on hand	95 15
	$155 00

Very respectfully,
SAM'L M. BARTON, *Treasurer.*

SEWANEE, TENN., November 26, 1913.

To the President, Tennessee Academy of Science:

DEAR SIR—I have the following report to make of receipts and expenditures since my last annual report at the annual meeting at Knoxville, November 29, 1912:

RECEIPTS.

Balance, November 29, 1912	$ 95 15
By cash for advertising (Dr. Gordon)	4 50
Received on dues for 1912	7 50
Received on dues for 1913	91 00
Total	$198 15

EXPENDITURES.

Dec. 8, 1912, Paid W. A. Nelson, for stenographer	$ 5 00
December 17, 1912, Stamps for Treasurer	1 00
February 1, 1913, Stamps for Treasurer	2 00
February 7, 1913, University Press, for notices	2 25
February 10, 1913, Foster & Parkes Co., for stationery	9 00
April 21, 1913, Science Record, for 50 subscriptions	100 00
Total expenditures	$119 25
Balance in Treasury	78 90
	$198 15

Very respectfully,
SAM'L M. BARTON, *Treasurer.*

PART II

Papers and Addresses Presented at the First Meeting,
April 6, 1912

Reported Discovery of Radium in Northern Arkansas

By A. H. Purdue, State Geological Survey.

In this day new results of scientific work make such rapid appearance that the public in general are very credulous about reported discoveries, however unreasonable they may appear, and even scientists are cautious about expressing adverse opinions concerning such, without having carefully investigated them. Apropos of this, a short article that some weeks ago appeared in a St. Louis paper, reporting an alleged discovery of radium in northern Arkansas and naming the writer as authority for its existence, has been somewhat widely copied by the press, and has brought numerous letters to the writer from different parts of the country from New York to California. Among these have been letters from scientists and those engaged in commercial work. The foundation for the report is as follows:

In the latter part of February, 1912, there came to the writer's office, then at the University of Arkansas, a Mr. Lieb, of Bentonville, that State, who brought a cigar box of earthy material that he said came from a cave near his home. It was just such material as might come from any limestone cave. With the box was a photograph which Mr. Leib said had been made by exposing the box containing the material before a camera, for several hours, in an absolutely dark room. The picture was of about the distinctness of an ordinary X-ray photograph. It plainly showed the box, the string about it, and the knots in the string.

Mr. Leib was told by both Prof. A. A. Steel, of the University of Arkansas, and myself that while the photograph was interesting, careful investigation was necessary before it could be stated that the substance contains any radium or other radio-active material. For this purpose he was advised to send some of it to Prof. B. B. Boltwood, of Yale University.

Such is the basis of a newspaper story that seems to have attracted a good deal of attention.

Some Remarkable Phenomena of the Tornado in Montgomery County, Tennessee, April 29, 1909

By James A. Lyon, Southwestern Presbyterian University, Clarksville, Tenn.

The general atmospheric conditions favoring the occurrence of tornadoes in the Mississippi Valley are fairly well known to meteorologists, so that it is possible to predict from six to thirty-six hours ahead, that tornadoes may be expected in certain general regions. Thus the observer at Nashville, after studying the telegraphic reports of weather conditions over the country, may announce, at 8 A. M., "Look out for tornadoes in North Louisiana, Arkansas and Mississippi this afternoon, and in Alabama and Georgia tonight and tomorrow." But, as the exact locality where a tornado is likely to occur cannot be predicted even within one hundred miles, nor the exact time, within several hours, such predictions are of little or no practical value, and are not published, as they would rather tend to terrify than to protect the people.

It is well known that the general movement of the atmosphere over the United States is from west to east, and that there is a constant procession of great vortices or whirls, whose rotary motion is counter-clock-wise, drifting eastward in the general movement of the air, like the eddies and whirls in the current of a great river. These are properly called "*Cyclones,*" and are of great size, measuring from 500 to more than 1,000 miles in diameter. At the center of a cyclone the barometer is relatively "Low." These cyclones are more marked in the winter and spring seasons than at other times, and generally follow one another across the country at intervals of about three days, and are separated from one another by areas of *high* pressure, sometimes called "anti-cyclones."

It is the passage of these cyclones across the Mississippi Valley which generally brings about our changes of weather. Here in Tennessee the center of the cyclone generally travels on an eastward or northeast track lying to the north of us. The winds flow in toward the low center; so after a spell of clear, cool weather, as a cyclone approaches from the west the winds set in toward its center, thus passing over us from the east, changing to southeast and south winds as the center gets more nearly north of us, bringing moisture from the ocean and Gulf of Mexico, forming clouds and rain. As the center passes on, the winds whirl round, blowing from the west and northwest, the barometer rises and the temperature falls and we come under the influence of a high-pressure area or "anti-cyclone."

Now in the spring and early summer, when the sun is rapidly coming north, we find from experience that these atmospheric changes are intensified, and then it is that the dreadful "*Tornado*" is most likely to occur. It is a notable fact that tornadoes are not most frequent very close to the center of the cyclone where the pressure is lowest, but from two hundred to eight hundred miles south or southeast of that point—most frequently about six hundred miles distant. Usually, when conditions are favorable, a number of tornadoes, following approximately parallel paths, occur over the same general region on the same day. On February 19, 1884, there were as many as forty. The tornado has a narrow and comparatively short track, usually from five to twenty miles long and a quarter of a mile or less broad, and lasting altogether generally less than an hour, while its duration at any one point may be less than a minute.

The tornado near Clarksville, Montgomery County, on April 29, 1909, about 8:30 P. M., illustrated very clearly, in its general features, the laws just noted. On the morning of that day, as shown by the weather map published at Nashville, there was a marked cyclonic center in Eastern Kansas, close to Kansas City. By the next morning it had advanced to Northern Indiana and Southern Michigan, so that at the time of our tornado it must have been about central Illinois—some five hundred miles north of us. Also the weather records show there were several other tornadoes in our general region near the same time. Moreover, on the day of the storm, which occurred about 8:30 P. M., the temperature had risen at Nashville to 20° above that of the preceding day for the same hour, and this was followed shortly by a fall of 24°.

The track of this tornado was followed and closely studied for six or seven miles. The beginning of its destructive work was at a point on the road from Clarksville to Nashville known as "The Telephone Road," four and a half miles southeast of Clarksville. Here the road runs up a creek valley. Some tree tops were twisted off to the south of the road here, but the destructive vortex seems not to have reached the ground until it crossed the road which runs along the base of the hill. Here was the house of Henry Brown, which seems to have been a little to the left of the central line of the storm track and was not much injured; outhouses and trees were overthrown.

From this point the track ascends the hill going through some open land. On top of the hill a log stable was torn to pieces and wreckage strewn over the surface of a pond. It is said that a fish supposed to have been sucked up and carried off with water from this pond was found on the ground several hundred yards further on.

Beyond the pond was the humble home of old man Stafford. It was completely wiped away and the ground swept clean. The old man was killed and his dog also. A little further on at the forks of the road stood Mt. Olivet schoolhouse, comparatively new and apparently strongly built; surrounded by a grove of fine tall trees. Here the track of destructive action seemed only about fifty yards wide. The building was torn to pieces, some parts of it carried backward, in the direction from which the tornado came, thus proving conclusively the rotary movement of the winds. Most of the trees were thrown toward the north, but some were piled crosswise on these.

In most places, all along the track, destructive action was more marked on the right or south side of the storm's path. But on both north and south sides the fallen trees generally pointed inward toward the path of greatest destruction. This seems to prove a strong *suction* toward the center along the surface of the ground. Portions of this schoolhouse and its furniture were carried forward and dropped many miles away. The storm track seems to make an angle at this point, changing for a while to an almost due east course. Near here a piece of wood was found driven into a solid telephone post which was still standing.

After destroying the schoolhouse it seems that the tornado lifted a little, or became more diffused and less intense, as there was less evidence of destruction, and the house of Mr. Swift, which appeared to be in the line of the storm's path, was unhurt. From this point the track lay for some distance through open fields and nothing remarkable was noted.

About three miles from the starting place it crossed the Clarksville and Port Royal pike, at an acute angle, going northeast through the Anderson place, swept a cabin away, which was at the top of a slope, and, descending on the other side, it destroyed the Anderson barn, but only partially damaged the residence, which was a little to the left of the track. Just here it passed squarely over a deep sink-hole with very steep sides. This sink was estimated at fifty feet deep and perhaps two hundred feet in diameter.

The work of the tornado here was very remarkable. Instead of skipping across this deep hole, as might have been expected, its destructive power was manifested down to the very bottom of the sink, which was full of trees. The trees were smashed off and forced down into the hole on all sides, some of them falling in the very teeth of the advancing storm.

Just beyond this sink hole a large old house, occupied by Mr. Dunn, was torn to pieces and caught fire and burned up.

Next the track crosses a deep, but rather wide, valley or ravine. Here the trees were mostly twisted off some distance above the ground; but after ascending the slope and coming to the brink of a steep declivity, instead of jumping across, the blast of air seems to have rushed down the steep slope and the trees were destroyed down to the bottom, almost as in the sinkhole.

Going further, to the Henry Whitfield place, the tornado fell upon the house of Mr. Cox. Here houses and fences were swept clean away and a heavy grove of oaks nearby smashed and splintered in a wonderful manner. The family was blown out of the house and scattered about, one boy had a leg broken and another's skull was fractured, but neither fatally hurt. A little beyond this place a large sycamore tree stood to the right of the track in a low place. Most of the limbs and top were torn off and large pieces thrown clear across the track and left on the other side.

Further on was the Welsh place, a strongly built log house, standing about fifty yards to the right of the storm track. It was not completely destroyed, but so badly twisted and wrenched as to require complete rebuilding. Parts of it were completely swept away. The family was not injured, though articles of furniture were blown or sucked out of the house and completely lost. Chickens had the feathers picked off them here and elsewhere and many of them were killed. Mr. Welsh stated that he heard the roaring sound as the storm approached and opened the door and saw the revolving funnel-shaped cloud mass, illuminated throughout by a constant play of lightning flashes. As already stated, the vortex of the storm did not strike this house; it passed about fifty yards north of it, through a bare field where there was a great deal of chert gravel on the ground, and it was wonderful to see how the blast had scooped up and carried forward this rough gravel and pelted small bushes and tough saplings a little further on, beating off every bit of bark and small twigs, completely skinning them, so that the countrymen said they had been *burned* (presumably by the electric fire in the funnel). But the skinning was evidently done by the sharp chert gravel. Here also were seen good sized cedar trees torn up by the roots and carried along in the whirl for some distance and cast aside completely stripped and peeled.

Beyond this the tornado reached the top of the high bluff of Red River, striking it obliquely. Here also the blast descended the steep, high bluff with tremendous violence smashing the timber down to the very water's edge, and some of the trees were thrown backward as in the sink-hole at Anderson's.

The storm then followed the river for several hundred yards, destroying trees on both sides of the stream (which is narrow) until a bend was reached, when it ascended the bluff and pursued its way across the fields, and the track could be seen about a mile further on ascending a wooded slope and cutting a path through the forest growth. It is said to have gone straight on and into Robertson County ten miles or more.

GENERAL OBSERVATIONS.

1. The destructive track of the storm was about fifteen miles long in this county (Montgomery), varying in width and intensity, generally from two hundred to four hundred yards.

2. Occasionally trees and buildings a good distance from the center of the track suffered more than some that were nearer—showing "flaws" in the winds.

3. As nearly as can be inferred, the whirl was "counter-clockwise," or "laevo-gyrate" (left-handed), with most destruction on the *right* or southeast side of the track.

4. No evidence of very excessive rainfall appeared, though in some places along the center of the track there is evidence of a mixture of water, light trash, chaff, etc., plastered against trees and bushes.

5. There is no doubt of the whirling character of the storm. Trees on each side of the line of greatest destruction have fallen inward towards that line, and fragments of houses and other things are scattered out on each side of the track, often beyond the region where the trees are broken. These seem to have been thrown out from the top of the funnel after having been drawn in below and carried up.

6. Two persons claim to have seen a revolving funnel-like form, with lightning playing through it incessantly. Many report hearing a great roaring sound. As the time of occurrence was after dark, most people were shut up in their houses at the time.

7. All agree that the duration of violence was not more than a minute or two, which is probably a full estimate, as observers, under such circumstances, are more likely to overestimate the time than the contrary. This proves it was advancing swiftly, but there were no data proving exactly how fast.

8. The most singular thing of all was the condition of the deep sink-hole at Anderson's, where all surrounding objects seem to have been thrown into the sink, many large trees, on the northeast edge of the sink, being thrown *back* in the teeth of the advancing storm. We venture as an explanation of this the following: The revolving funnel hugging the surface of the ground as it moved along, formed a very strong partial vacuum by centrifugal force, at the same time forming a sort of *wall* around the

central vacuum, preventing the ready inrush of air from the outside. But as the friction against the ground would check the velocity at that point and the irregularities of the surface of the earth would from time to time make gaps under this "*wall,*" blasts of air of great force would, in a somewhat irregular manner, rush into the central vortex with destructive violence. This explains the "flaws" already alluded to so that trees standing quite near together were sometimes very unequally damaged. Now, as this vortex comes suddenly over the deep sinkhole the lower edge of the "wall" of revolving air suddenly leaves the surface of the ground, on account of the rapid sloping of the ground downward into the sink; this allows surrounding air to rush from all sides, with tremendous violence into the vacuum, "diving under the wall," so to speak; and as these blasts are much more swift than the progressive motion of the funnel, trees are even overthrown backward.

9. It was noted that when the funnel passed suddenly over the edge of a steep bluff where the ground dropped suddenly downward, instead of skipping over as might have been expected, the destruction was worse than usual, even down to the bottom of the slope. This phenomenon may be explained on the same principle as in the case of the sink-hole.

10. It seems strange that there are not more lives lost in these terrible storms. Many times isolated houses are completely destroyed, and yet the occupants, though scattered about and much shaken up, escape serious injury. Contrast the destruction of a town by a tornado and by an earthquake. The loss of life is vastly greater in the earthquake; in this the house is shaken down upon the occupants like a "dead-fall" on a rat. But the tornado generally lifts the roof, bursts out the walls, scatters the materials of the house, often without damage to its inhabitants. The probable explanation of this is as follows: Suppose the house is tightly shut up, as is usually the case during the storm. Now when the vortex suddenly envelops the house, the air inside being much denser than that constituting the partial vacuum of the vortex, suddenly expands, lifting the roof and bursting out the walls. Calculations based on the probable difference of pressure inside and outside the house show force amply able to produce such results.

Selection of Food Among Lower Animals

By ASA A. SCHAEFFER, University of Tennessee.

All animals must eat food in order to live. The higher animals usually do not eat anything that is not food, but some of the lower forms, such as the earthworm, eat a considerable amount of material that is not useful for food. In a general way it has been assumed that the further we go down the scale the less precise is discrimination between food and other materials. This idea has in the past been responsible for the notion that discrimination in food does not occur in the one-celled animals, for these stand at the bottom of the scale. The expectation was, then, that these low forms of animal life ate all the different kinds of particles that they happened upon, whether of food value or not. This opinion was expressed by some of our foremost students of the protozoa, and their opinions have been generally held for a long time.

It was with a view of determining the truth of this notion that I carried out a number of experiments on several of these lower forms. A considerable number of test substances were employed, some of which were good for food, others not. The principal question to be solved was: Can a one-celled animal tell the difference between food substances and those that are not good for food? And if they can tell the difference, how can they tell it?

I wish today to report on a few experiments on stentor and on ameba that were designed to throw some light on these questions. Both stentor and ameba are of about the same size, being just barely visible to the naked eye, and live amid the same general surroundings, in ponds and other bodies of fresh water. These organisms are entirely different in structure. While each consists of only a single cell with a single nucleus, their body structure is as unlike as it can well be.

The stentor has a definite and permanent body shape which is covered with small hair-like organs, the cilia, which function as locomotor organs and also to create a vortex of water directed toward its mouth, by means of which food and other particles are brought to it. The ameba on the other hand has no definite body shape, no definite organs of locomotion, no mouth; it has, indeed, no specialized organs of any sort. Another difference between these two forms is that stentor frequently attaches itself to some solid support, while at other times it swims freely through the water. But the ameba neither fastens itself nor swims in the water; it glides over the surface of submerged objects like a snail does; but unlike a snail, it changes its shape continually, and what is at any given time the head end will be gradually transformed into the tail end.

Of these two forms the ameba is commonly regarded as standing much lower in the scale of living beings than stentor; indeed it is frequently referred to as the simplest animal known. A reference to figures 1 and 2 will serve to make clear to some extent the main characters of these forms.

We shall first take up some of the experimental work on stentor. The method of feeding was simple. A number of particles of the desired kind were sucked up with some water into a pipette of very small bore. The particles were then very slowly dropped on the stentor's disk and the fate of each one, whether eaten or rejected, was noted and recorded. The work was done under a binocular microscope magnifying sixty-five diameters.

As a first experiment I fed a few small organisms, known under the name *Phacus triqueter*, which were ingested; then a number of grains of sulphur were fed, but all of these excepting one, were rejected. Then some more phacus were fed, followed by sulphur grains. Again the phacus were eaten and the sulphur rejected. The experiment showed that the food discriminative powers of stentor as far as they apply to sulphur and food organisms, are nearly perfect.

In other similar experiments stentor discriminated almost perfectly between food organisms and starch grains (which stentor cannot digest), and between food organisms and powdered glass or sand grains. The degree of accuracy in discrimination ranged from about 90 per cent to 98 per cent. The same degree of discrimination was exhibited when a mixed stream of several different kinds of indigestible particles and several different kinds of organisms were fed.

After it was clear that stentor can discriminate between food substances and indigestible particles, the question arose whether stentor selected certain food organisms in preference to other food organisms. To determine this, several different kinds of food organisms were fed in mixed order. At first all the different organisms were eaten, but as the stentor became less and less hungry, one kind after another of the organisms were rejected until some little time before the stentor was satiated, only one kind of organism was eaten. These various food organisms, while they differed but slightly in size, varied greatly in shape of body. The results of these experiments interested me to the extent that I desired to see how delicate the sense of discrimination is in stentor. To test this, I was fortunate in having cultures of two kinds of small organisms that were not closely related, but were almost exactly alike in size and shape. It required a trained eye to tell the difference between them. These two kinds of organisms were mixed in equal numbers and fed to the stentor one by one. At first both kinds of organisms were eaten. As the stentor became less and less hungry, many of both kinds of organisms were rejected. But finally when nearly replete, only now and then would an organism be eaten, and it is very remarkable to observe that all the organisms eaten when hunger had nearly disappeared, *were of one sort;* the organisms of the other sort were all rejected.

We may conclude then that stentor discriminates in food with a degree of precision that is matched only, so far as we know, by that of the higher animals. And the observation that stentor discriminates more and more precisely as hunger grows less, is also paralleled in the higher forms. Even in man does this observation hold. When hungry almost any kind of food is eaten, but when hunger has nearly vanished, only such things as desserts are capable of stimulating the eating mechanism. There is therefore a remarkable degree of similarity in the feeding behavior of the highest animals and of stentor.

The ability to discriminate in a high degree having been shown to exist, the question arises: How is it effected? Since stentor does not possess any of the sense organs we possess, so far as we know, it is interesting to know in what way stentor can tell the nature of the particle that strikes its disk. Can stentor "taste" the particles or "feel" them?

In popular usage the word taste includes a number of qualities which properly do not belong to it. We say commonly, that we taste our food, but in a strict sense there is very little truth in the statement. We taste sugar, a few salts, a few "bitter" substances, and a few "sour" substances. We smell a large number of substances which are practically always associated with our food, but which themselves exist only in small quantities. We smell the essential oils in many fruits, the meat extractives, peptones, etc., but all these are present in very small quantity in the food we eat, and their actual food value is negligible. Most of the proteins (the plant and animal albumins, for example), the starches (whether soluble or insoluble), have no taste in the pure form, and these make up the bulk of our food. It is well known that the cooked white of a hen's egg is not an attractive tasting substance, nor is it really disagreeable; it is merely tasteless. If we had never seen or tasted coagulated egg albumin, and should come upon a mass of it in a place where we would not expect to find food, such as inside of a rock, we would most certainly reject it if tested by taking it into the mouth and chewing it. The reason that we eat it, is that we have learned to eat it, because we have observed that it is non-toxic and that it sustains life. Now this is also the case with the other proteins and the starches. We do not taste these substances themselves, but only the volatile oils which are associated with them. If we ate only what we taste and smell in our ordinary food, we would starve to death or die of acute gastritis. The point is that a number of other factors are concerned besides taste and smell in food selection.

I have called attention to these facts merely to show that there is good ground for discussing the basis upon which selection in food is made.

In order to contribute to the solution of the question: Does stentor learn what is food by tasting and smelling it, or by feeling of it? I carried out a number of experiments on this point which I shall describe briefly.

The main object of the experimental work was to change the taste of the organisms, or to change their form, surface texture, etc., without, so far as possible, changing the taste, to see what the effect would be on the stentor. A number of food organisms, phacus, were cooked and washed. They were then fed with living phacus in a mixed stream. The result was that the hungry stentors ate all the phacus whether cooked or living; and those that were partially satiated ate a few of both sorts and rejected the greater number of both. Other phacus were treated with iodine, quinine, acids, dyes, etc., then washed and fed with living phacus in a mixed stream. But again there was no selection. Cooking phacus and treating them with various chemicals should change their taste; nevertheless whatever change was thus produced, was without effect in their discrimination of food.

In other experiments the living food organisms were mashed up into a jelly. The form of the organisms was thus completely destroyed. This jelly was rejected. Not any of it was eaten. But if the food organisms were cut up into quarters or eighths, the pieces were eaten. In a few experiments starch grains were soaked for a few minutes in the jelly of the organisms and then fed to the stentor without washing. None of the starch grains were eaten. Starch grains were also soaked in raw beef juice, pork juice, pepsin, Liebig's Extract of Beef, sugar, etc., but in no case was starch so treated eaten.

Now taking all these experiments together, we see that when the taste of the food objects was altered, no change in discrimination resulted; but when the form and texture of the food substances were changed, marked effects on discrimination were observed. This leads to the conclusion that the stentor selects its food by a tactual sense; that the chemical sense, if the stentor possesses any, plays little part in the process. This conclusion need not be surprising. For what sort of a taste may a living animal have when it is swallowed whole with a quantity of water? It is only the excretory products that diffuse out into the water from a living animal. The albumins and other proteins, carbohydrates and fats do not diffuse out into the water, and these substances are practically the only food substances in the animal.

Some attempts were made to analyze the basis of selection still further, but without much success. However, it is pretty certain

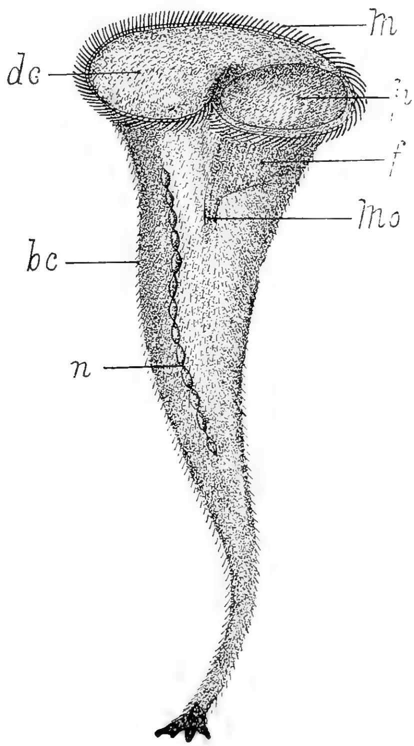


FIG. 1. The Blue Stentor (Stentor caeruleus Ehr.). *bc*, body cilia; *dc*, discal cilia; *m*, membranellae; *f*, funnel; *mo*, mouth; *p*, pouch; *n*, nucleus. A stream of water is brought against the disk by the action of the membranellae, *m*. Particles in the stream of water impinge upon the disk whence they are slowly carried to the pouch and funnel. If the particles are of food value they pass down through the mouth, *mo*, into the internal protoplasm; but if the particles have no food value, they are thrown out over the edge of the pouch. The stentor is shown in normal extended position attached to some solid support. Natural size of stentor, about three-quarters mm. long.

that selection is affected by more than a single quality affecting the tactual senses, such as weight, size, surface texture, form, etc. To stimulate the feeding mechanism, several of these factors must be present in a certain degree or form of expression; more than one of these factors serves as a basis of discrimination.

These experiments on stentor indicate that in the matter of food selection stentor compares favorably with the higher animals. The problem of food selection evidently does not begin with animals like stentor, for it is highly developed here. I was interested in knowing therefore whether in ameba, which as was said above, is supposed by many to be the simplest animal living, the problem of food discrimination begins; that is, whether there is any sign that the power of discrimination resides in ameba.

The method of work was as follows: A single particle of the substance which it was desired to test, was placed some distance ahead of the ameba, by means of very fine glass needles. Camera lucida drawings of the outline of the ameba were then made at intervals of about half a minute, as the ameba moved ahead. In this way a complete record of the behavior was obtained.

Instead of using living organisms for feeding ameba, isolated chemical substances were used. It was thought that by so doing the interpretation of the behavior would be simpler, for instead of having to do with a number of substances which are present in an organism, only one substance can be the cause of whatever changes are noticed. The number of variables and unknowns is thus reduced to the minimum.

The first question to be solved was: Does ameba possess the power of discrimination in food? It did not require many experiments to show that it does possess this power. In a general way we may say that, excepting carmine, which is eaten, only digestible substances are eaten. Not only does this hold true for organisms, living or dead, but for isolated proteins, such as the globulins and the albumins. Globulin, which is said to be insoluble, is readily eaten; but egg albumin, which is very soluble, is very seldom, if ever, eaten. Feeding experiments with ameba have not been carried as far as with stentor, but from the work that has been done, it seems safe to say that the power of discrimination is as highly developed in ameba as in stentor.

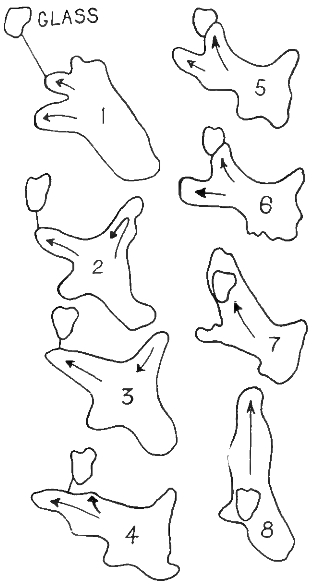


FIG. 2. Eight stages in the movement of an ameba (Amoeba proteus Leidy) drawn at intervals of about half a minute. A particle of glass was laid in the ameba's path, 1. The ameba became a little uncertain in its movement, 2. As the ameba moved forward past the glass, a small pseudopod was thrown out directly toward it, 4. This pseudopod became the main pseudopod through which the ameba moved away over the glass without any further change in behavior incident to the glass. Stage 4 illustrates the sensing of glass at a distance. Natural size of ameba, about one quarter mm. in length. The arrows indicate the direction of movement of the protoplasm.

More interesting than the fact that ameba can discriminate in food is the observation that an *ameba can sense objects at a distance*. Not only is this true of soluble particles, but of insoluble as well. A fragment of clean glass, one-twentieth millimeter in diameter, is sensed by an ameba at a distance of one-tenth millimeter. That is, the ameba moves toward the glass particle in a direct line after changing its direction, if the particle is placed to the side of the ameba's probable path. This has been observed in a number of cases, so it cannot be said that it is a matter of coincidence only.

Reaction to an object at a distance by an ameba is a remarkable phenomenon, for this animal has no specialized sense organs of any sort. This makes it difficult to determine how the presence of the particle of glass is sensed before contact is made. Glass is, of course, very slightly soluble, but it must be remembered that the observation was made with the ameba moving on a glass surface; so that even if the glass particle was soluble, its effect on the ameba was cancelled by the solubility of the glass surface over which the ameba moved, the glass particle being a fragment of the dish in which the experiment was made. See Fig. 2. Some work has been done to determine in what way the ameba senses insoluble particles at a distance, but no definite conclusions have been arrived at. This work is still in progress.

From the work on stentor and on ameba it may be concluded then that the unicellular animals possess the power to discriminate in food, and that they exercise this power in a high degree. The observations on ameba show also that an unlooked for sense, that of becoming aware of objects at a distance, is present in ameba.

Voltaic Action in Combination Teeth Fillings

By JOHN DANIEL, Vanderbilt University.

My attention was directed by personal experience to the practice among Nashville dentists, and, presumably, among dentists in general, of using what they call "combination fillings;" that is, tin fillings topped with gold. This combination gives no serious voltaic or electrical disturbance *in case the base metal is entirely covered by the gold, and is at no point left exposed to the saliva.* This is probably the way it was intended to be used by the originator of the combination fillings; but the case is very different when *both metals are left exposed at any point to the saliva.*

In my own experience, which is a case in point, I had ordered gold fillings and thought I had them; but in a very short time the base metal was dissolved away, undermining the gold cap. A discussion of the case with my dentist disclosed the fact that the fillings were combination fillings. My experience of having the base metal dissolved away when placed in contact with the gold is exactly what should be expected, and is fully explained by the well established laws of electricity.

On page 305 et seq. of General Physics, by Henry Crew, Professor of Physics in Northwestern University, is found the following statement concerning voltaic action: "The simple and well established facts of the voltaic cell are as follows: At the very close of the eighteenth century it was discovered by the Italian physicist, Volta, that all conductors of electricity can be divided into two classes. This division is based upon the following experiments. If we make a closed circuit out of several different metals, *i. e.*, if we make an endless chain in which each link is composed of a different simple substance, such as zinc, copper, gold, or tin, we see that no electric current is produced. All substances which when joined together at the same temperature in any order, produce no current, are called conductors of the first class.

"Volta found, however, that if into a circuit such as the above he introduced one link composed of a compound substance, such as dilute brine, or sulphuric acid, or copper sulphate, he *always* obtained an electric current. Conductors of this kind, which Volta called conductors of the second class, *always* undergo chemical decomposition when introduced into a circuit containing two different metals, and *always* yield a current.

"The modern name for a conductor of the second class is electrolyte, *i. e.,* any substance which is decomposed when a current passes through it. Conductors of the first class practically include only carbon and the various metals.

"Definition of a voltaic cell. It has been found by experiment that no two conductors when joined together will produce a current so long as they are at the same temperature. But the following combination, suggested by Volta, and named after him, 'the voltaic cell,' will always give a current: *The voltaic cell is defined as three or more conductors in series, each conductor being made of a different substance, and not all belonging to the same class.*"

It is thus very clear that gold and tin, two conductors of the first class, and saliva, a conductor of the second class, constitute clearly a voltaic cell, and the inevitable result of such a combination is just what takes place in every voltaic cell when two metals are put in contact and both are dipped into an electrolyte—a current flows and the baser metal is dissolved.

A number of prominent dentists whose attention has been called to this matter have assured me that this theory, and my own experience, are confirmed by their own observation. However, there are some who deny voltaic action in combination fillings. I consider it of scientific and economic importance that this matter be given wide publicity both among dentists and among the general public, for if there are dentists who insist upon imposing upon their patients in the use of combination fillings, our only defense is to let the public know the facts in the matter so that we may refuse to be imposed upon by such practice.

It should perhaps be again emphasized that voltaic action is only to be expected when *both metals are left exposed to the saliva.* However, as thermo-electric disturbance may be expected with the variations of temperature, as indicated in the above laws, it is my opinion from the standpoint of an electrician, that combination fillings are in no case to be preferred to pure gold.

Some Effects of Parasitic Fungi on Leaf Tissue

By E. S. REYNOLDS, University of Tennessee.

(*Abstract.*)

A considerable amount of information has been gathered in the past upon the general effects of parasitic fungous invasion upon the cell contents of leaf cells. It was found by numerous microtome sections that the cells are affected in quite diverse ways, depending upon the particular disease and the particular host studied. In some cases the cell organs are killed, evidently by a very strong poison, while in others the organs are stimulated into excessive growth, resulting in enlarged nuclei or an increase in their number. In still other cases the nuclei are greatly changed in form, from crescentic to obovoid or irregularly dumb-bell shaped. Some of these latter forms seem to precede or to be the result of direct division of the nucleus. The chloroplasts most often are reduced in size or are missing entirely. The general cytoplasm seems often to be changed into, or replaced by, oil drops, or at times a granular deposit, the composition of which was not determined. These changes are equivalent to those which have been previously reported by others as occurring in other kinds of parasitic tissue.

Other Papers

Addresses or papers, manuscripts of which are not available for publication, were presented at the meeting of April 6, 1912, as follows:

"Neon and Wireless Waves," by W. L. Dudley, Vanderbilt University.

"Rock Striations and Their Causes," by C. H. Gordon, University of Tennessee. Published in "The Science Record," Vol. I, No. 1, February, 1913.

"Railroads and Road Building in Tennessee Before the Civil War," by G. W. Dyer, Vanderbilt University.

"Food and Drug Inspection in Tennessee," by Lucius P. Brown, State Pure Food and Inspection Bureau.

"The Beginnings of Music," by R. M. Ogden, University of Tennessee. Published in "The Psychological Bulletin," Vol. IX, No. 5, May 15, 1912.

"Review of History of Geological Work in Tennessee," by L. C. Glenn, Vanderbilt University. Published in "Resources of Tennessee," Vol. II, No. 5, 1912, pp. 167-219.

"A Washing Apparatus for Mixed Microscopic Material" (illustrated), by S. M. Bain, University of Tennessee. Published in "The Science Record," Vol. I, No. 1, February, 1913.

PART III

Papers and Addresses Presented at the Second Meeting, November 29-30, 1912

Science and Progress in the South

By C. H. Gordon, University of Tennessee.

Introduction.

On first coming to Tennessee some years ago I took occasion to investigate the status of organized science in the State. Investigation showed the following results: No Geological Survey, nor had the State given support to one for forty years. Up to that time the sum total of appropriations for geological survey work probably totalled not to exceed the amount now appropriated biennially. No Academy of Science or other organization having like aims. In the State University there were two departmental organizations, but no general scientific society, and if any such organization existed elsewhere in the State it did not come to my notice. Five years have passed and the progress made is cause for congratulation. A Geological Survey has been in operation for two years with results comparable with the best surveys of the country. We are now celebrating the second meeting of the State Academy of Science, and by the vitalizing influence inspired by these efforts, the Joseph LeConte Society which expired many years ago has been recently revived at the State University; and no doubt investigation would reveal corresponding advances in other centers. I am convinced, therefore, that we stand in the dawn of a great scientific advance in Tennessee and the South, a progress in which I trust this society is to have a conspicuous part.

Progress of Science in Recent Years.

Until recent years no review of the progress of science was considered adequate which failed to give, as the crowning achievement, the triumph of steam and its application to navigation, railroading, etc.; the triumph of electricity as represented in the telegraph; the use of waterpower, etc. So familiar are these now in our everyday affairs that we scarcely recognize in them a modern achievement. It is scarcely conceivable that the first effective use of the railway locomotive was in 1830, and that the first passage of the Atlantic by a boat propelled by its own steam power was made in 1838 by the Sirius of London, the trip requiring nineteen days. Four days after the departure of the Sirius from Cork, the Great Western left Bristol making the passage to New York in thirteen days and five hours. It is interesting to note that, not long before, Sir Joseph Banks, in a lecture before the Royal Society, had said, "That the application of steam to navigation was a pretty plan, but there is just one point overlooked: that the steam engine requires a firm basis on which to work." And in 1838, the same year in which successful trips were made by the Sirius and Great Western, in an address before the Royal Institute Dr. Lardner "proved" to the satisfaction of himself (and his audience presumably) "that steamers could never cross the Atlantic because they could not carry sufficient coal to raise steam enough during the voyage."

The achievements of those early days which had been so discounted were but stepping stones to the still greater achievements of these latter times, which, in the application of electricity in industrial lines, wireless telegraphy, the navigation of the air and other accomplishments in the field of science has witnessed a progress that makes one to pause before making declaration that any proposed achievement is beyond the bounds of possibility.

Part Played by Societies in the Progress of Science.

While the study of the progress of science shows that the mountain peaks of achievement in every generation are a direct outgrowth of the labors of certain individuals, nevertheless contributory thereto were scores of lesser lights and influences without which success would have been impossible. Prof. Osborne, in an address on a like occasion, has well said: "Science is essentialy mutualistic, and the success of one individual or of one organization is the gratification of all—the triumphs and discoveries of one are shared with the many, and the feeling of pride in the progress of one may be shared without loss with others."

Coincident with the great advance in science has been the establishment of associations of scientific workers whose activities have tended greatly to promote the scientific work of their age. And much of the progress along social and economic lines is to be attributed directly to the great advances made by science. England's progress is coincident with the establishment and growth of the Royal Society. It has been said that "in olden times this country (England) possessed the materials for great things as well as the men fitted to develop them into great results." But the nation was slow to awake and take advantage of its opportunities. There was no enterprise, no commerce, no "go" in the people. The roads were frightfully bad, and there was little communication between one part of the country and another. If anything important had to be done, foreigners were called in to teach the people. An English writer says: "We sent for them to drain our fens, to build our piers and harbors, and even to pump our water at London Bridge. Though a seafaring population lived around our coasts, we did not fish our own seas, but left it to the industrious Dutchman to catch the fish and supply our markets." (Samuel Smiles, Invention and Industry, p. 45.)

Even to the casual observer, the analogy between the condition thus depicted in old England and those of the South must come with telling force.

Without entering at present upon a discussion of the tardy progress heretofore made by the South in education and social welfare, the causes of which are not far to seek, it may be pointed out that there has been a like absence both of notable achievements in science and of organizations which might serve as a stimulus for such work.

Among the first and most notable organizations of this character in this country are the American Philosophical Society and the Academy of Natural Sciences of Philadelphia, The Brooklyn Academy of Arts and Sciences, The American Academy and the Boston Society of Natural History of Boston, and the St. Louis Academy of Science. Inspired by the success of these organizations, sprang up such as the Chicago Academy of Science, the Philosophical Society of Washington, etc., which, though possibly of lesser prominence, have in their way rendered most important service in promoting the cause of science in their respective communities. State Academies of Science like this of ours are of relatively recent origin, and have flourished particularly in the central and western States. Among those deserving special mention are the Academies of Iowa, Michigan, Wisconsin, Illinois, Indiana, Minnesota, Nebraska, California, Ohio, Kansas, Colorado, Utah, Maryland and last of all, Tennessee.

One of the particular functions of a State Academy is that of serving as scientific adviser to the State in which it exists. It has been well said that this function alone constitutes a sufficient basis for the organization of such societies in every State.

In an address before the Iowa Academy of Science, Prof. H. Osborne has called attention to the fact that in many instances geological surveys, biological surveys, topographical surveys and other enterprises dependent upon State support have had their origin in or have received their support and encouragement from the State Academies.

As may be seen from the enumeration given of State Academies of Science, Tennessee is the only State in the South that has such an organization. With the awakening of this giant in the Southland, must come that organization of all the forces of science and the arts which is necessary to the right utilization and conservation of the great resources, material and human, of this part of our country. In this work the Academies of Science in the various States are destined to play a prominent part. And in this great work we trust that our own Academy shall serve as a stimulus and an example pointing the way of progress and high achievements.

Suggested Lines of Activity of the Academy.

What has been said, however, is merely preliminary to some suggestions I desire to make touching the future work of the Academy. The organization must find its justification in what it does for its members and for the State. If it shall serve no other purpose than as a stimulus for scientific work among its members, it will amply justify its existence. But above and beyond all, let us see to it that it shall be felt in the promotion of every enterprise tending to conserve the material and human resources of our State.

In this connection, permit me to outline a little more specifically some views as to the lines along which the efforts of the Academy may well be directed.

1. As already suggested, a fundamental feature of a Society like this is to correlate and to stimulate the efforts of those interested in Science. By the interchange of views through papers and discussions and by the inspiration that comes through personal contact and association, enthusiasm will be aroused which goes far to overcome the inertia of dull routine and to ward off the insiduous approach of indifference to the weal or woe of the other man.

2. The influence of the Academy should be exerted (1) in the support of the present Geological Survey, both by encouragement to its achievements and by urging upon the authorities the importance of ample financial support. And (2) of urging the establishment, as opportunity offers, of other enterprises, such as a Biological Survey of the State, a State Conservation Commission, whose functions shall be to provide for the conservation of the material and human resources of the State, including the waterpowers, forests, minerals, and other resources and conditions affecting the material and social welfare of the people; and other like enterprises.

3. Another and equally important phase of Academy work should be the promotion of education, and especially of science teaching in the public schools. The great awakening to the importance of education in these last years brings with it profound responsibilities as to the character of the work done in the schools and the provisions made to meet the demands for the best results. In view of previous conditions, it will not be strange if the authorities fail to recognize the paramount importance of providing not only a sufficient number of thoroughly educated teachers of science, but the equipment necessary for the proper handling of the work. About the last thing that the ordinary school officer realizes is that in order to give the proper kind of instruction, fewer pupils and classes should be assigned to the teacher of science than to the teacher of almost any other branch.

It should be the privilege of the Academy to stand for better equipment and for the best teaching of science in the schools. To this end, I would suggest that there be joint meetings of the Academy and the high school teachers of science for the consideration of the best methods of science instruction and the stimulation of a zeal for the best results?

Recommendations.

In closing, I desire to make some recommendations concerning the work of the Academy.

1. By-law 1 provides that any special department of work may be assigned to a curator, whose duty it shall be, with the assistance of other members, to promote the work of that department. I would therefore recommend that a Department of Science Teaching in the Public Schools be created and a Curator placed in charge.

2. It is a well known fact that owing to neglect, the advantages of our State in material resources and physical conditions are little known outside its borders and to relatively few within. During the next three years, three Expositions are to be held, each of which will offer unparalleled opportunities for publishing to the world the nature of our resources and the progress we are making along industrial and educational lines. These are the National Conservation Exposition in Knoxville, in 1913; the Exposition at San Diego, 1914, and the Panama Exposition at San Francisco, in 1915. The importance of providing for exhibits at each of these Expositions should be urged upon the coming legislature. A bill providing for an appropriation to prepare suitable exhibits for each of these Expositions is to be presented, and I would recommend that the Academy endorse such a bill and urge upon the members of the legislature its passage.

3. If time permitted, I would like to discuss at greater length the great importance of the museum as an educational factor. The Europeans are far ahead of us in their appreciation of this means of instruction. Few indeed are the places there without their museums and collections, to visit which constitutes one of the chief ends of the American traveler. Take for example the British Museum, which is the Mecca of the investigator in every line of study, as well as a school of instruction for the ordinary visitor. In America, coincident with the awakening of civic consciousness, has come the recognition of museums as one of the important elements of the social and intellectual progress. Thus, New York, on putting her swaddling clothes aside, began the upbuilding of that great institution, the New York Museum of Natural History. The growth of the Museum idea as pointed out by H. F. Osborne is due to the fact "that this institution is not

a conservative, but a progressive educational force; that it has a teaching quality or value peculiar to itself; that the museum succeeds if it teaches, fails partially if it merely amuses or interests people, and fails entirely if it simply mystifies."

The State museum is a natural outgrowth in the promotion of State Geological Surveys. The value of the museum as a means of becoming acquainted at first hand with the varied productions of the State is everywhere conceded. An example of one of the most noted institutions is the New York State Museum, the outgrowth of a Survey which "gave to American geology a nomenclature largely its own and demonstrated above everything else the value of fossils for purposes of correlation and incidentally brought into prominence one man, James Hall, who was destined to become America's greatest paleontoligist." *

As a result of its first real effort to maintain an adequate geological survey, Tennessee is emerging from geological obscurity and the need begins to make itself felt for the building up of a State Museum. One of the functions of the Geological Survey is to develop such an institution, but its efforts in that direction are handicapped by the lack of suitable quarters for housing the collections. As a result of this, valuable material that should remain to interest and instruct our people goes elsewhere. It should be one of the first duties of the State to provide a suitable building for a good museum and sufficient funds for its maintenance and growth. I would, therefore, suggest that the Academy seek to promote the establishment of a State Museum and to that end recommend the appointment of a standing committee whose duty it shall be to take this matter in charge.

4. There are in Tennessee two other societies which aim to do for their respective branches what the Academy seeks to do for the allied interests of Science in the State; these are the Tennessee Philological Society and the Tennessee Historical Society. I believe that the amalgamation of all three organizations would be greatly conducive to the interests of the causes represented by each. Inasmuch as the scope of the Academy of Science is sufficiently broad to include these as well as other allied lines of work, it has been suggested that each be incorporated and made

* Merrill, Geo. P., Report U. S. Nat. Mus., 1904, p. 344.

a section of the Academy. I would recommend, therefore, that a committee of three members of the Academy be appointed to confer with representatives of the other societies with reference to such amalgamation and report at our next meeting.

The present is the second session of the first year's existence. The growth of its membership, the character of its programs, and the interest manifested augur well for the future of the organization. It can render a high service for the State and for the South. The better to perform this mission we need and should have a large membership. The members are urged, therefore, to invite others to join the Society and assist in all the various ways that suggest themselves of extending its work and influence.

Contributions on the Feeding Habits of Ameba

By ASA A. SCHAEFFER, University of Tennessee.

Last spring I reported before this Academy the results of some experiments on the feeding behavior of ameba. I reported then that the ability to discriminate in feeding resided in ameba, and also that ameba is able to sense insoluble objects, such as glass, at a distance. Since our meeting in April I have obtained additional evidence on these two points, all of which is confirmatory, and I have also obtained some experimental data which extend our knowledge of the feeding habits of ameba in various directions. I wish now to speak briefly of these findings.

Since reporting on the presence of the power to discriminate in food in ameba at our last meeting, I have tried a number of additional substances, some of which are eaten, others not. Below is a table which presents the results in compact form:

TABLE I.—THE BEHAVIOR OF AMEBA TOWARD VARIOUS TEST SUBSTANCES.

Substances Eaten.	*Substances Refused.*
Many sorts of one-celled organisms.	Arrowroot Starch.
Aleuronat.	Carbon.
Ameba fragments.	**Casein.
*Carmine.	Cholesterin.
Crab Meat.	Cobalt.
Egg White.	Corn Starch.
Fibrin (Blood).	Cotton.
Globulin (Egg).	**Egg Yolk.
Globulin (Eye).	**Gelatin.
Grain Gluten.	Graphite.
*India Ink.	Hematin.
Keratin.	Indigotin.

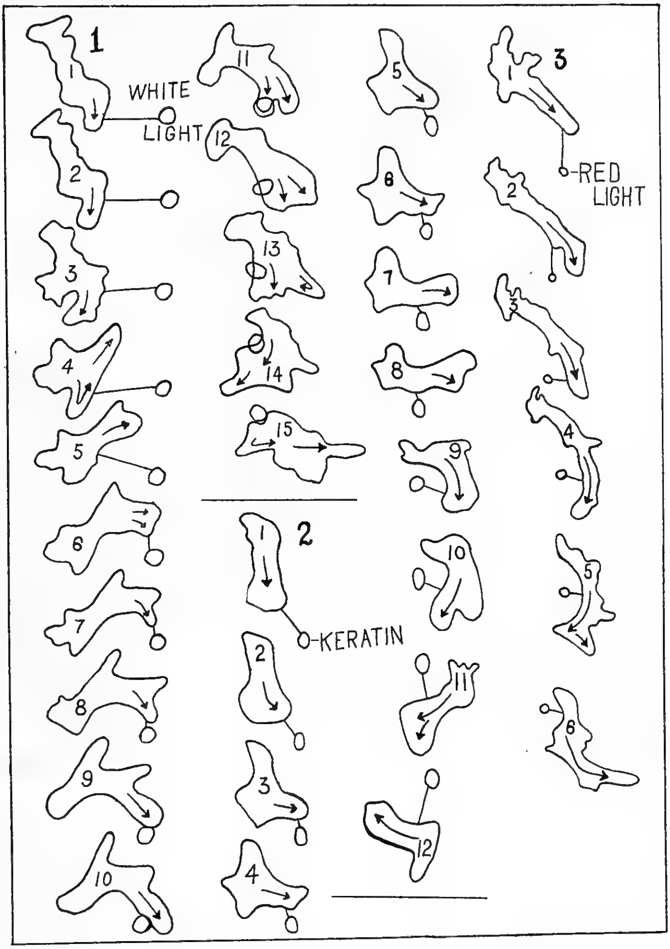
* Valueless as food; ** Of food value.

Substances Eaten.	*Substances Refused.*
Lactalbumin.	Iron.
Ovalbumin.	(**?) Lecithin.
Peptone.	Milk Sugar.
Tyrosin.	Silicic Acid.
*Uric Acid.	Sodium Chloride.
	Uranium Glass.
	Zein.

This table is of interest in that each column includes some substances which, from the viewpoint of value as food, should be in the other column than the one in which they occur. These are exceptions, it is true, to the statement that ameba discriminates in food, but it must be remembered that physiologists have not yet been able to define the word *food* from the viewpoint of sense perception, and we can hardly expect ameba to do better than we can. To show that an animal can discriminate it is not necessary that absolutely no "mistakes" be made; the food selective mechanism varies in the ease with which it may be set into operation, and this variable must be taken into account. But the most interesting feature of the table, as has been said, are the exceptions, for in these, doubtless, lies the explanation of the method by which selection is made. Experiments on this point are still in progress, for no definite conclusions concerning the method of selection have yet been arrived at.

But I have made some observations that may have some bearing on the basis of selection of food particles, such as grains of protein, carmine, and the like. I have found that by mechanically agitating particles of the proper size with very fine glass needles, amebas could be induced to eat the particles. All sorts of particles, whether digestible or not, are eaten if properly agitated. Not only is it unnecessary for the agitated particle to lie in contact with the ameba, but vibrations produced by the tip of a needle are likewise reacted to, positively if the needle point is one-fiftieth of a millimeter or more from the ameba. We may be certain, therefore, that water vibrations proceeding from a definitely localized source are an efficient cause for successful feeding. If the vibrations arising from a non-toxic particle are of

* Valueless as food; ** Of food value.



FIGS. 1, 2, 3. Reactions of ameba (Amoeba proteus, Leidy) to white light, keratin, and red spectral light. The arrows indicate the direction of protoplasmic streaming. Natural size of amebas, about 0.25 mm. long.

FIG. 1. Reaction of an ameba to a small beam of white light. The tendency was at first to move away from the perpendicular beam of light, stages 1, 2, 3, 4. Positive behavior then set in and the ameba moved in a curved path into contact with the beam, stages 5 to 10. The ameba partly surrounded the light, then moved off.

FIG. 2. Illustration of an ameba encircling a grain of horn (keratin). Although pseudopods were formed at 8 and 10, leading away from the horn, nevertheless the ameba moved around the test object about 270 degrees. By an oversight stages 3 and 4 were repeated in 5 and 6.

FIG. 3. Illustration of an ameba partly encircling a beam of red spectral light.

the proper sort, it will be eaten, no matter what the composition of the particle is. Now, when it is remembered that ameba, in its natural state, lives practically altogether on living organisms, it appears that movement in a particle is an adequate stimulus to set off the feeding mechanism; for movement can be sensed at a distance from the particle, and movement is always associated with a food organism. It may be concluded then that the ameba's chemical sense, if it has any, might atrophy without materially impairing the ameba's effectiveness in feeding. That is, the tactual sense is much more important in food discrimination while the ameba is in its natural state than a chemical sense would be.

This discussion concerning food discrimination refers only to discrimination preceding the final stage of complete ingestion; for after ingestion some particles are quickly excreted while others are kept in the body for a long time. That is to say, there is a form of selection outside the body which differs from that inside the body; some substances, such as carmine, are readily ingested, but usually quickly excreted, while other substances, such as grain gluten, which are usually less readily eaten than carmine, are retained for a long time. It is evident, therefore, that discrimination can not be made upon the same basis in both cases. To avoid confusion while speaking of food discrimination, it is therefore necessary to keep this distinction in mind.

I reported at our last meeting that amebas are capable of sensing objects at a distance; that they can accurately locate, for example, a piece of glass at a distance of one-tenth of a millimeter. I have carried out a number of experiments since then that show that vertical beams of white or monochromatic spectral light, one-fiftieth of a millimeter in diameter, can also be sensed at a distance of about one-tenth of a millimeter. The amebas move toward the light beam before they come into actual contact with the beam. (See Fig. 1.) One could, therefore, in the experimental results, change "fragment of glass" for "beam of light", and *vice versa,* without necessitating a change in the character of the reactions of the ameba. This makes it clear that any quality which necessarily attaches to any solid object is not the quality that stimulates the ameba from a distance; the quality that stimulates the ameba is one that is common to the particle of glass and the beam of light.

Not only do amebas react to beams of light at a distance, but also to what we may call for convenience, dark beams. The technic is more difficult, however, in working with dark beams and the results are less definite. The amebas react positively in most cases to beams of light, but to dark beams the reactions are more frequently negative. It remains unknown why there should be this difference.

Particles of glass, carbon, and various food substances were placed in light and in dark beams to see what the effect would be on ameba. In general it may be said that the amebas are not disturbed when a food object lies in a beam of bright light, but when lying in a dark beam the ameba is clearly disturbed and feeding is often forgone.

These observations extend considerably our information concerning reactions to objects at a distance, but just what the qualities are in objects which are thus sensed is still entirely unknown.

One of the most interesting observations that I have made in connection with the feeding experiments is, that ameba sometimes moves neither directly toward a stimulating object, nor directly away from it, but moves around it, encircling it, while it is still some distance from the object. All classes of substances are thus encircled: glass, carbon, food substances, beams of light, etc. The reason for this peculiar behavior can not then be laid to the nature of the particle but must be due chiefly to the internal condition of the ameba, guided to some extent by the stimuli received from the particle.

Encircling seems to take place whenever the stimuli coming from a particle are not sufficiently strong to produce movement directly toward the source of the stimulus, nor weak enough to be ignored by the ameba. But these conditions would not be sufficient to produce encircling such as we see in ameba. Such conditions would doubtless produce uncertain behavior, but it would not necessarily express itself in encircling the test object. There must therefore be another factor present in ameba which is concerned with encircling. This factor is a tendency to continue moving forward after movement is once started. The ameba seems to acquire some sort of a momentum of reaction, which tends to keep amebas moving in more or less straight paths. Such a tendency balanced against stimuli producing mild positive behavior would result in encircling movements as illustrated in figures 2 and 3.

This tendency to move in a straight path is not very strong, as might be expected; but when external stimulation is not very strong or is not definitely localized, the tendency to move in a straight path is stronger than the tendency to change the direction of movement in accordance with some external or internal stimulus. When the tendency to move straight ahead is of about the same strength as that to react to some external stimulus, encircling movements result. It is possible that this tendency to move straight ahead is found in other animals. Some of the experimental data obtained by other investigators seem to indicate that it may be present in other protozoa, but it would probably be necessary to carry on experiments especially to prove the presence of this factor. But if it should prove to be present in other forms, it must be regarded as an essential factor in movement, a factor which must not be overlooked in investigations touching any phase of movement.

Hydrogen Peroxide as a Bleaching Agent for Entire Insects

By E. C. COTTON, University of Tennessee.

(*Abstract.*)

Notes on the bleaching of entire insects in order that the chitinous exoskeleton, the muscular structures and the viscera may be studied *in situ,* independently and in their relations to one another.

Relation of the State to Its Water Power Resources

By J. A. SWITZER, University of Tennessee.

(*Abstract.*)

The paper gave a resume of the procedure of certain other of the states in dealing with the question of state ownership or control of water power, and discussed the subject with special reference to the present situation regarding water power development in Tennessee.

The Recent Disturbances in the Northern Equatorial Belt of Jupiter

By LATIMER J. WILSON.

(*Abstract.*)

Presenting a series of observations showing some remarkable changes which have occurred since August (1912) in the north-

ern equatorial belt of the planet. The proper motions of markings seen in the belt are compared with those observed in 1911 in the tropical and sub-tropical regions of the southern hemisphere of Jupiter. A general discussion of these proper motions.

The paper was published in "The Science Record," Vol. I, No. 1, February, 1913.

The Effect of a Soy Bean Crop on a Following Cereal

By MAURICE MULVANIA, University of Tennessee.

(*Abstract.*)

1. A mature crop of soy beans injures a following cereal. 2. The growth does not seem to decrease the soil nitrogen. 3. Beans cut for hay do not produce the inimical effect. 4. The experiments did not indicate the presence of a toxin. 5. The system, soil, beans and nodules, shows a gain in nitrogen up to the hay stage of the beans. 6. The bacteria of the soy bean nodules probably never form distinct branching.

The Fourth Dimension

By SAMUEL M. BARTON, University of the South.

(*Abstract.*)

In this paper the author gives a non-mathematical exposition of hyper-space. The aim of the paper is to make clear to the "layman" what is meant by the fourth dimension or space of any dimension higher than three. To this end the subject was of necessity treated in an elementary manner and at considerable length. In particular it is shown that while our experience teaches us nothing of space other than that of three dimensions, the conception of hyper-space is perfectly reasonable. The nature of the paper precludes giving an abstract of it.

This paper was published in "The Popular Science Monthly," October, 1913.

The Mastodon and the Glacial Age

BY W. E. MYER.

(*Abstract.*)

A description of the Mastodon unearthed by W. E. Myer in Marshall County, Tenn., in July, 1912. The evolution of the Mastodon, Mammoth and elephant from the small Moeritherium of the Eocene in Egypt. The Mastodon closely identified with the Glacial Age of the Pleistocene.

The three great glacial ages in Cambrian, Permian and Pleistocene. Remarkable climatic conditions during some of these ages; warm and temperate at the poles, cold and great fields of ice on the tropics of Cancer and Capricorn. Man and the Mastodon. The lecture was illustrated with twenty-five lantern views, as follows:

(1) A restoration of the Mastodon from Gleeson's Picture in National Museum.

(2) Photo of Jumbo, Siberian Mammoth and Newburg Mastodon.

(3) Restoration of Newburg Mastodon.

(4) Mounted Skeleton of Newburg Mastodon.

(5) Mammoth from Indiana.

(6) Head and Tusks of Great Texas Imperial Mammoth.

(7) Right fore leg of Texas Imperial Mammoth.

(8) Palatal view of skull of Texas Mammoth.

(9) Photo of teeth of Texas Imperial Mammoth, the Indiana Mammoth and Siberian Mammoth.

(10) Photo of Mastodon tooth.

(11) Group of ancestors of elephant.

(12) Texas Imperial Mammoth and a small relative.

(13) How this relative, the Trilophodon, secured its food.

(14) Evolution of head of elephant.

(15) Evolution of Tusks.

(16) The Paleomastodon.

(17) Internal section of head of Paleomastodon.

(18) External appearance of Paleomastodon head.

(19) Moeritherium.

(20) External appearance of head of Moeritherium.

(21) Internal section of same.

(22) Map showing location of ice in Permian.

(23) Boulder beds of Australia.

(24) Map of North America in Pleistocene.

(25) Map of Eurasia in Pleistocene.

Diffraction Phenomena Due to the Dimensions of the Source of Light

By BROWN AYRES, University of Tennessee.

(*Abstract.*)

A diffraction phenomenon of great beauty is produced by passing sunlight through a short focus cylindrical lens and then through a square mesh gauze. The disturbing action of the apparent diameter of the source of light as seen from the guaze causes the disappearance of the shadows in the plane perpendicular to the cylindrical lens. The mathematical theory is of great complexity and difficulty. At a moderate distance from the gauze the appearance is that of a brilliantly colored cloth. Farther away the regular spectra are seen within and without the geometric shadow of the wires.

The Green Slates of Georgia

By T. POOLE MAYNARD.

(*Abstract.*)

The green slates of Georgia are the only known commercial green mica slates occurring south of Vermont. They occur in Bartow and Gordon Counties and are found in the Connasauga formation of Cambrian Age. The Connasauga formation attains a thickness in Georgia of 2,000 feet, and is made up of shales, slates and limestones. The slates are found in this formation only where all conditions of sedimentation and local metamorphism have been suitable for the changes to take place. In places the slates are found where quarries can be worked over a width of 250 feet, length of four to five hundred feet and to any depth commercially possible.

The Breaking of the Nashville Reservoir, November 5, 1912

(Illustrated.)

By WILBUR A. NELSON, State Geological Survey.

(*Abstract.*)

On November 5, 1912, at 12:25 a. m., the east basin of the Nashville reservoir broke.

The cause of the break was the character of the rock formation upon which the walls were built. The limestone contained thin bands of shale, which the action of water had turned to clay. It was upon one of these clay seams where the rocks dipped locally about eight degrees from the reservoir that the slip occurred. The entire wall with about four feet of the limestone upon which it was built swung outward. On either side of the main break several smaller breaks occurred.

Slides were used showing diagrams of the reservoir, the breaks in the wall, the mashed rocks and the damage to the surrounding property.

Types of Iron Ore Deposits in East Tennessee

By C. H. GORDON, University of Tennessee.

(*Abstract.*)

The deposits of iron ores in East Tennessee are of three types. Along the eastern side and elsewhere in the Great Valley are deposits of brown ores (Limonite). In these deposits the ore occurs in residual clays resulting from the disintegration of the underlying rocks through agencies of weathering, the concentration of the ores being due to the operation of these agencies throughout the long period of time. The ores occur in masses or pockets in the superficial clays, a fact that has to be taken into account in their commercial exploitation.

A second type is the red or brown Hematite deposits found in the Tellico formation. These result from the weathering of a highly ferruginous calcarious sandstone or sandy limestone. Deposits of these ores of apparent promise occur in the Tuckahoe district above Knoxville, near Englewood, Sweetwater and elsewhere. In depth they are limited to the reach of weathering agencies, usually from five to forty feet.

The red fossil or Clinton ores found in the Rockwood formation along the western side of the Valley constitute the third type. These occur in beds two to four feet thick, and because of their more persistent character have greater commercial possibilities. Their origin is disputed, but evidence seems to favor their accumulation in low-lying areas during Clinton time, although probably concentrated more or less through weathering agencies since being deposited.

The different types are discussed and their commercial possibilities pointed out.

Other Papers

Papers and addresses, manuscripts of which are not available for publication, were presented at the meeting of November 29-30, 1912, as follows:

"The Taste Sense in Frogs," by Alice N. Porter, University of Tennessee.

"The Occurrence of Aerial Roots in the Virginia Creeper," by S. M. Bain, University of Tennessee.

"Micro-Color Photography," by S. M. Bain, University of Tennessee.

"The Importance of the Study of Meteorology in Its Relation to Agriculture," by J. F. Voorhees, United States Weather Bureau.

PART IV

Papers and Addresses Presented at the Third Meeting, November 28, 1913

An Unnoticed Physiographic Feature in Tennessee

By L. C. Glenn.

(*Abstract.*)

Safford and others have long since made us familiar with two prominently developed plains in Tennessee; the lower one known as the highland rim and the higher one as the Cumberland Plateau. In the vicinity of Sparta, Bon Air, Cookeville, and north toward Livingston, where these two levels are well developed, the Cumberland Plateau being some 800 to 1,000 feet above the highland rim, there is also an intermediate level well developed that has heretofore escaped notice. It consists of numerous flat-topped areas, some of considerable extent that rise 300 to 400 feet above the highland rim. They are prominent just north, east and south of Livingston. Just east of Algood is another area well seen where the Tennessee Central Railroad crosses it, in its climb from Algood to Monterey. They are again seen well developed about Sparta in numerous spurs and ridges.

An inspection on the ground shows, as does the geological map of the Standingstone area, that they are due to the resistance to erosion offered by a sandstone found in the Newman formation. This sandstone forms a flat surface that is often poorly drained and has a thin, poor soil that is much less desirable agriculturally than the surrounding limestone soils of the highland rim. These flat sandstone areas are in consequence not inviting to settlers and have been largely left uncleared.

The level marked by these sandstones has not been traced southward toward the Alabama line, but it is believed not to be prominent in that direction and may disappear altogether before the state line is reached.

Recent Developments in the Tennessee Phosphate Industry

By LUCIUS P. BROWN, State Food and Drug Inspection Bureau.

Within the past five years a revolution has been wrought in the methods of mining Tennessee phosphate rock which is of enormous importance to the industry at large, and particularly to that section of it located in this State.

I may preface my paper by saying that, as is probably known to many of you, Tennessee prosphates occur in four different geological horizons. From above downward these are as follows:

First, the so-called Kidney phosphates, occurring in the Devonian member of the Paleozoic, lying below the black shale and immediately above the lowest member of the series. These phosphates occur as nodules of varying sizes, of fine grained texture, of concentric structure, with a smooth exterior, rarely glazed, and in color from gray to dark, brownish black. Occurring as they do in a layer, usually limited in thickness to not over two feet, and the nodules themselves lying in a matrix of barren material, from which they are separated with difficulty, this horizon has given rise to no important industry. The nodules are occasionally used in mining the next lower layer.

The latter, forming the so-called blue rock of Tennessee, is the lowest member of the Devonian of the State. It varies in composition from an argillaceous phosphatic material through real phosphate rock to an arenaceous layer containing at times only traces of phosphate. The layer appears to be co-incident with the occurrence of the Devonian over a large area. It certainly extends all over the State of Tennessee, and it or its representative appears to occur from Pennsylvania to Oklahoma. Only very locally is it of much value. It is now being mined at only one point, namely, at Mayfield Mines, twenty miles west of Mt. Pleasant, where a phosphate rock containing from 65 to 70 per cent of tri-basic phosphate of lime is being mined by the Charleston Mining & Manufacturing Company. Forming, as the material does, one of the rock layers of the country, it is mined as a flat lying coal seam is mined. The method of mining has not changed appreciably, and we may dismiss it, for our purposes, without further notice.

Lying geologically below this, but in an entirely different territory, namely, along both sides of the Tennessee River and adjacent streams, occurs the so-called white phosphate, which appears to be analogous in its methods of formation, and in its occurrence, to the hard phosphate rock of Florida, with the important difference that it occurs in the Niagara member of the Silurian instead of a Tertiary limestone. A further important difference is that it is not so widely distributed as is the hard rock of Florida. It has given rise to no important industry.

In the Ordivician occur the really important horizons of phosphate rock in Tennessee, leaving out of consideration certain economically unimportant deposits. These all owe their origin to the occurrence of a phosphatic limestone. When this limestone is free, or comparatively free, from other ingredients than carbonate of lime and phosphate of lime, its disintegration under sub-aerial conditions gives rise to an economically important phosphate of lime deposit, through the removal of an easily soluble carbonate, and the leaving behind of the more difficultly soluble phosphate. Of very minor importance in the formation of these deposits is the transport in solution from the other portions of the bed of limestone phosphate, and its redeposition through an interchange of constituents in solution in the lowest portions of the deposit. Of course, any clay or sand in the original limestone remains behind when the carbonate of lime is leeched out, with the result of a more or less phosphatic leeched layer containing one or the other of these materials; and it may be said, broadly speaking, that to the discovery of methods of utilizing certain of such deposits is due the revolution of the phosphate industry to which I have alluded above.

The normal aspect of a deposit of this so-called Tennessee brown rock is that of a loosely built wall of dry masonry, the irregular plates of hard phosphate rock lying fairly close to one another and separated only by a sandy layer of the same material.

For ten or twelve years after the discovery of the deposits only this lump or plate rock was mined. In most cases everything below one inch in diameter was thrown away. This included the material lying between the plates, which differed in composition from the plates themselves only by containing from, say, 5 to 25 per cent less phosphate of lime, and a considerably larger proportion of sand and clay. The latter, together with the iron content in all clays or loams, was not, for the purpose of manufacture, an inert material, but was decidedly objectionable, causing the manufactured material, the so-called acid phosphate, to dry out slightly, and to contain less of the valuable soluble phosphate. There were two methods of cleaning this plate rock, namely, drying in the sun, and screening and washing in a crude way with water. In the latter process settling ponds were, of course, necessary to prevent stream polution by the waste materials. It was recognized some years since that the waste in this process was enormous, and that if the phosphatic material in the waste products could be saved, it formed not only a certain source of profit, but the material itself was fairly close to the condition of fineness to which the rock was afterwards reduced by the manufacturer, thus necessitating only one manufacturing operation.

About five years ago most of the miners in the field began to depart from the old crude methods of mining, and to save this material by utilizing well-known principles of settling in water for the purpose of settling the phosphatic sands, as they are called, from the siliceous or argillaceous components of the raw material. It is obvious further that if a phosphate deposit consists wholly of such comminuted material (as indeed many of them do), the same process is applicable to its utilization, when under the old methods it must be left alone. The problem involved, while not specially difficult, presents certain questions of its own. Ore separation by means of water is dependent chiefly upon two factors, namely, the specific gravity of the material handled, and the size and shape of the particles. The clay, sand and phosphate do not differ greatly in specific gravity, and a certain important portion of the phosphate material does not differ greatly in size from the clay particles. It is obvious, therefore, that the differences in specific gravity do not admit of separation, and that advantage must be taken as far as possible of the differences in the size and shape of the particles. The latter point, namely, the shape of the particles, is of prime importance. The clay usually exists in flakes, the phosphate in more or less rounded or concretionary shapes, often almost microscopic. The latter, therefore, forms a true sand, and does not have the same properties of suspension in water that the clay has. A further complication is the presence of lumps of pure clay in the phosphate desposits, which must be disintegrated by super-mechanical means. The following briefly stated principles have been enunciated by Mr. J. A. Barr for the theoretically perfect phosphate-sand washer: First, the velocity of the water should not be more than 4-100 of a foot per second; second, the clay must be thoroughly disintegrated, and should travel in one direction by reason of fineness, shape and properties of suspension in water, the sand settling out or traveling in an opposite direction by reason of its greater settling power. To effect a perfect separation of clay and phosphate-sand the clayey water must be washed from the phosphate-sand by the repeated addition of clean water.

Practically all the companies in the field utilize these principles in their plants. It must be borne in mind that in the Mount Pleasant district the lump or flake rock and the sand are dumped into a hopper, and a stream of water from a large hydraulic nozzle played upon it. Fed gradually from the hopper to a flight conveyor, run over a screen of inch and a half mesh, the large material is carried up an incline, passing under sprays from perforated pipes, which carry the fine material through the screen. The large lump is then separated from the smaller lump by passage over a grill. From both sizes of lump the clay balls are removed by passing across a picker belt, from whence the clay is picked out by hand. The fine material which has passed through this inch and a half screen is crushed through rolls, and goes to a collecting tank; thence it is carried up by pulsometer pumps to washing bins, holding about sixty tons of dry material. While these bins are being flooded and emptied the flow of dirty water therefrom is regulated by gates in the side of the bin, which are so handled that about five feet of water is kept on top of the sand deposit and at the gate. In this way the clay and very fine particles of silica sand and phosphate-sand are in a large part removed. When the tank is filled a few minutes are allowed for final settling and the water drained off by pulling the gates down to the top of the mass of sand. The sand is then washed out by a hydraulic nozzle into another tank, from which it is lifted a second time by a pump to a tank corresponding to the first used. This operation being repeated four or five times, practically all the clay is removed from the phosphate-sand, and the product is finally carried to a very much larger settling tank, where it is allowed to stand for forty-eight hours, in order that the water may drain off. The lump, having been cleaned as first mentioned above, goes along with the sand to rotary driers, where it is dried down to not over 2 per cent moisture. It is further to be noted that the water which passes over the gates of the tanks during the process of filling is conducted along settling troughs with bottoms inclined to a central hopper, where the finest material is caught and utilized. It is claimed that the special advantage of this material is that no additional finestuff is made, as is the case when lump rock is passed through log washers.

Plant No. 2, one of the most recently installed in the field, uses hydraulic giants for mining. These guns, as they are called, wash the rock into a sump located as close as possible to the center of the area being mined. This particular deposit has very little lump rock, 85 per cent of the material being phosphate sand. When the material has been washed into the sump by the guns, eight inch centrifugal pumps take up the slush and carry it to a plant about a quarter of a mile away. Here the stream is discharged into a double log washer, of which there are two sets in tandem. These discharge into wash trommels, where the lump and sand are separated. The lump goes to a picker belt for the removal of the clay, and thence to the wet storage pile. The dirty overflow water from the logs goes to a settling tank, which also receives the sand from the wash trommels, and these wash trommels, as will be noted, act also as sizing screens. The settling tank is a box 15 by 30 feet in plan, the bottom consisting of forty-eight pyramidical boxes, into which water is fed from below, the principle being that of the whole-current box-classifier. The settling tank discharges into four riffle trough launders, in which run flight conveyors. These launders have a slight upward incline at the discharge end. The sand travels with the flights against the current of water. They discharge into cubical boxes, five feet on the side, with a hole in the center, which are themselves discharged intermittently by an attendant. The phosphate-sand, of course, piles around this central hole, so as to form a cone, and in effect the boxes are pyramids instead of cubes. These discharge on to the wet storage pile, which is not covered over. After drainage in this pile the rock is fed to driers of the ordinary rotary type, and from the driers is lifted to a tower, in which is set a sizing screen, by which the product is made into two sizes, lump, pebble and sand. This plant appears to be designed on systematic lines, and the company claims excellent results from its operation of about twelve months.

It is obvious that this process has brought into use, or can bring into use, deposits that were unavailable under the old methods, and that it has further greatly conserved the supply of phosphate rock in Tennessee. As a matter of fact, a not inconsiderable proportion of the production of the past few years has been obtained from settling ponds, a photograph of one of which is here shown. I estimate that something like 200,000 tons of material has been taken from this pond since this work was begun. It is further obvious that if a practical method of screening phosphates can be devised it may be possible to use this process or an analogous one in bringing into use very large deposits of sandy phosphatic material which cannot now be used.

In the latter connection it is to be noted that such material is very abundant throughout a large part of the Middle Basin of Tennessee. It differs from the deposits consisting chiefly of phosphate sands in being of a lower grade, not decayed, and in containing considerable silicious sand. The method is not so promising, therefore, for such deposits as for the thoroughly weathered deposits, but at this moment offers possibly the best starting point for experiments in utilizing such low grade material.

It may be remarked at this point that the actual phosphate resources of Tennessee are ample for any call upon them which can be foreseen within any reasonable length of time, provided these low grade phosphate deposits can be utilized. They cover areas of hundreds of square miles, and exist as unaltered phosphatic limestone ranging in content of phosphorus from six to ten or twelve per cent. Sundry methods for the utilization of this material have been proposed. The efficacy of ground limestone has been thoroughly established by a recent agricultural research. A fine phosphate limestone would add to the soil at a reasonable cost both carbonate and phosphate of lime. I am not aware that the material has thus been utilized as yet. Various processes have been devised which may utilize low grade phosphates which are dependent upon the heating of the raw material in contact with other cheap materials. For this purpose one of the most promising appears to use an iron compound, if I am rightly informed—the ordinary liminite ores of this section. One process doing this uses the ordinary rotary cement kiln. Various compounds of the alkali methods have been tried, but it would appear that their cost is against their economic utilization. The use of salt is, of course, not practical on account of the introduction of chlorine. I have heard rumors also of the mere heating of the material to a high temperature being effective, but have been unable to get anything definite along these lines. It would appear that the presence of silica in the impure phosphate might lead to favorable results if it were possible to form lime silicate instead of lime phosphate through the intervention of a material acting as a katalyst. At any rate, many men are working on the problem, and it is not supposed that it cannot be solved.

In the meantime, as far as my knowledge of the field goes, it is not advisable to place any restrictions around the industry in order to prevent exportation from the state of the high grade material. Under present conditions there is enough of this alone to last for many years. It would be more to the point to encourage research into methods for the utilization of the low-grade deposits.

The Caverns and Rock Shelters of the Cumberland Valley

By W. E. Myer.

For many years I have been interested in the exploration of the caverns and rock shelters of the Cumberland Valley. In discussing the matter with several scientific friends I found they agreed with me in believing that the valley of the Cumberland offered an ideal location for primitive man at the end of the last glacial period, if he were here at that time. If anywhere in the Union traces of man contemporary with the early cave man of Europe could be found it would be here. The caverns in the river cliffs of our valley are easily defended, and many of them moderately dry and would make admirable dwelling places for savage man.

Within my own county, Smith County, along the river bluffs are found many such caverns. I have carefully explored many of them, and, much to my surprise, have been able to discover no traces of their having ever been used as dwelling places.

Practically all of them which have entrances easily closed to keep out wild animals have been used as burial chambers. Another surprise to me was that the aborigines did not appear to have buried their most important dead in these caverns. I have found dozens of bodies in these caverns, but never any with fine gorgets or other insignia of high rank. The ornaments and vessels have always been inferior. The persons of rank, judging from their ornaments, were always buried in the great sepulchral mounds, which are found at many places in our valley.

There are at Castalian Springs, in Sumner County, of this state, the remains of one of the largest Indian towns east of the Mississippi River. It contains several mounds. One large mound about three hundred feet long and twenty feet high, and two small mounds about eight feet high and eighty-five feet in diameter. The largest mound was explored by other men, as recorded in

Haywood's History, and as shown by traces of their work of exploration. This large mound proved to be a house or temple mound not used for burial. One of the smaller mounds proved to be probably the richest mound ever explored in the United States. It contained one hundred and twenty-five graves. Many of these graves yielded remains of great scientific interest, shedding much new light on the habits and thoughts of the aborigines. Some of the bodies buried therein bore insignia of high rank. One man especially must have been of the highest rank. He was buried with four exquisite gorgets on his person. These gorgets were not only of the most elaborate workmanship, but one of them showed decided Aztec influences. The elaborate and much bedecked human figure (holding in one hand the severed human head of an enemy, and in the other a peculiar instrument partaking both of the nature of a sword and a war club), engraved thereon being almost an exact counterpart of many similar figures shown in the Aztec codices and on many of the sculptured stones of the Aztecs.

I show herewith one of the many beautiful cliffs on my beloved Cumberland River. This cliff is about one mile from Carthage. At the point touched by arrow-head, opening on a narrow ledge on the edge of a vertical precipice, at least seventy-five feet high, is the small entrance to a most remarkable burial cavern. This entrance is so low and narrow that it is necessary to crawl in. The opening had once been entirely closed with stones, which are yet around the interior of the entrance. This narrow entrance is on the extreme verge of the precipice, where a careless step would send one to instant death. It opens up into a spacious burial cavern about twelve feet wide and eight feet high and forty feet long. The rock floor has a layer of about six inches of earth. This earth contains the remains of innumerable human bones. On natural ledges of rock around the sides of the cavern were still found many human bones. Tradition says that when this cavern was first opened there was found a considerable amount of pottery and beads. When I explored it these had all been removed.

At the rear of the cave I found a small opening, near the roof, which I was able to reach with some difficulty. It was just large enough to enable me to crawl through it. Hoping this might lead to an unexplored portion of the cavern, I attempted to crawl through. Right there I saw a gruesome sight, the memory of which will remain with me as long as I live. At the end of this narrow opening, in a hollow in the rock, about level with my eyes, was a pile of bones partially decayed, ghastly, slimy white in the dim light of my candle, and literally alive with a mass of pale, sickly white, crawling worms. The sudden and unexpected and close coming upon this hideous mass gave me a shock that I will never forget.

Not many people know of the existence of this cave and still fewer care to visit it.

The following burial caves, nearly all of them small at the entrance, are located within a few miles of my home at Carthage, and nearly all have been explored by me: Alexander's, High's bluff, Farley, Petross and Nunley's bluff. Nunley's bluff is the site of Old Cuff's cave. Old Cuff is a name to conjure with in this section. Whether Old Cuff was some eccentric early white settler or an Indian I have never been able to learn. Certain it is that the fishermen around Old Cuff's cave attribute all unexplained noises and all bad luck to Old Cuff. There is a beautiful streamlet running along the floor of this cave and making a beautiful little waterfall to the river below.

ROCK SHELTERS.

We now come to inhabited rock shelters, known in some sections of the state as rock houses. In the day of primitive man in our valley these rock houses were favorite places of abode. All over the valley, wherever is found a cliff projecting sufficiently to afford reasonable shelter and facing to the south, so as to afford warmth, you are certain to find traces of early human occupancy.

I show herewith a rock shelter under a cliff on Caney Fork River, near Sebowisha Station. I dug up an Indian there. The ashes and kitchen refuse showed plainly human occupancy by primitive man. The beautiful stretch of river in this picture is interesting from the fact that here, about thirty years ago, the first commercially important pearl was discovered in the Caney Fork Valley. This pearl, selling originally for a few dollars, passed from hand to hand, at an ever-increasing price, until it finally sold for $2,000.00. This excited the people and was the begining of the pearling industry on the Cumberland and Caney Fork Rivers, which afterwards brought many hundreds of thousands of dollars into that section.

The next is the most interesting rock shelter it has ever been my good fortune to discover. It faces almost due south and is sheltered by adjoining bluffs, to a considerable extent, from east and west winds. South winds are the only ones reaching it. South winds are usually warm. I have no doubt that this shelter has been inhabited during all the time savage man has lived in this section. An old trapper friend kept telling me of a place where Indians had lived. He continued promising to disclose its hiding place, but always had some excuse for delay. Finally the real reason cropped out. I was so anxious to see it that my old trapper felt certain the Indians must have buried silver there. Somehow it is always silver that the ignorant believe is buried with the Indians. This is almost an universal belief in this section that the Indians left great hordes of buried silver. When I learned the real trouble I told him that, if he would show me the place, I would pay him to help me dig and would also give him all the gold and silver we found. That I was only after the dead men's bones and the little trinkets buried with them, and the information to be gained therefrom. He thought I was half crazy, but showed me the burial place.

My walks and talks with this old trapper friend were full of interest and instruction. It was many long years before Ernest Thompson Seton. To my old trapper the soft earth or the dust of a path or the ashes of this rock shelter was the plain printed page of the every day life of the wild things. He it was that knew of the last otter slide the banks of the Cumberland were to ever see. He would stop me and show where the coon had passed and tell his probable errand. Here the play of the mice in the ashes. There the skunk had dug for worms. I remember his calling my attention to some small depressions in the soil, saying, "I will set my traps here and catch this old pole cat. He was here last night and comes here regularly to dig for worms."

My old trapper was the wildest and the wisest old animal in all those glorious woods.

The long promised burial place I found was this rock shelter. The debris at the base of this rock shelter is composed of rock fallen from the cliff overhead and ashes and refuse from human occupancy. It has a depth of at least thirty feet. I was able to explore to a depth of only about five feet. You see the excavation as I left it about twenty years ago. It shows how slowly the rocks fall. Practically no rocks have fallen during this time.

The ashes contained the usual kitchen refuse of Indians and showed they ate practically everything that flew in the air, or ran on land, or swam in the water. Turkey and turkey buzzard, fish and periwinkle, deer and snake, were all grist for his hungry maw.

A strange custom (if any custom can be called strange, for all customs are strange to those who do not have them), was that of burying the bodies of little children under the hearth fire, and then continuing to use the hearth as before. When I came to this I was much puzzled until, by further research, I found that it was a custom of many Indians to do this. Professor Putnam found many such burials under the old wigwam sites of the old Indian town on Greenwood farm, about 20 miles from this rock shelter. I have since then discovered many other similar burials. Some day, when my ship comes home, or some rich man furnishes the $1,000.00 required, I want to explore this shelter to its base. I believe that at the base will be found traces of the earliest man this section ever saw.

Here is a view of a large cave nearly opposite the town of Carthage. This was never used for burial, nor, as far as I can discover, as a dwelling place. It is interesting as showing the possibilities of cave exploration. On the solid rock floor of this cave is about eighteen inches of earth. From a hole, about twenty-four inches square and extending down to the original rock floor, I obtained the partial remains of many of the wild things which, living or dead, find their way into lonely caverns.

The strange part is, that in this small hole, I was rewarded by finding the remains of a bat of South American type that was new to North America.

It is remarkable what can be discovered by keeping your eyes wide open. In the rough box house of a saw mill man at Carthage I found a queer jaw bone. I learned he had found it in a cave in the Cumberland Valley near Ashland City. This proved to be the jaw of a fossil porpoise from the Cretaceous period. It was found at a point where, up to that time, no Cretaceous remains had ever been discovered.

I have recently obtained from Mr. Joseph Lightman a portion of the teeth of a Mastodon which was found in a cave or sinkhole in the Lightman quarry in the suburbs of Nashville. This cave or sinkhole has not as yet been fully explored. It is filled with earth and debris that have washed in from above and can only be explored when more of the surrounding rock has been blasted away, as the quarry is enlarged in the regular course of business.

This cave promises to be of great interest for it will likely yield remains of other animals contemporary with the Mastodon and the early cave man.

Food Preservatives

By CHARLES L. BLISS, State Food and Drug Inspection Bureau.

It is not an easy matter to treat a subject as broad and as important as Food Preservatives in as thorough and comprehensive a manner as it deserves in a limited space of time. However, I will endeavor to cover the ground as well as I can, giving a little attention to the general aspects of the subject and taking up only the more common preservatives and treating them in a general rather than a detailed way.

Many foods being very prone to decay it was quite natural that dealers and manufacturers should cast about for some method of keeping them in good condition 'till they could be disposed of. Of course sterilization or refrigeration answers the purpose best, and to these should be added the careful selection of the food itself, using only what is in good condition and fit for food, since mixing bad with the good contaminates all. But sterilization and refrigeration are not always practicable or easily accomplished, or may require increase in operating expenses; and further, much of the material which ought to be rejected can be utilized if skillfully treated. So what is more natural in these days of high cost and close competition than to cut out these expenses of sterilization, refrigeration and rejection of material and accomplish the end by the addition of a little chemical preservative? Besides the heat necessary for the proper sterilization of some foods, detracts from their appearance, while chemical preservatives do not produce such effects; on the contrary, they sometimes enhance the appearance.

Meats can be preserved by drying, smoking, salting, or pickling; these processes were used ages ago just as they are being used today, and there is no objection to them when properly done. But nowadays some of the butchers want a quicker method of smoking hams than by the old smokehouse way, so they soak the meat in a "liquid smoke"—a solution of crude pyroligneous acid, and thus cut down the time from weeks to hours. Or they may have on hand some meat that is getting old and is beginning to show it; they can make it up into hamburger steak and with the addition of a little sulphite not only keep it from spoiling but brighten it up and make it look like fresh meat.

As we all know, only a very small quantity of preservative is necessary to accomplish the purpose sought, and such a quantity may not be injurious in itself, at least for most of us. We are not all alike, however. Some may have an idiosyncracy for that particular substance; others may have weak stomachs, their digestion easily disturbed; and there are invalids and infants to be considered. All of these must be thought of as well as those who are strong and healthy.

Another argument against preservatives is that the use of some of these substances, even though in small amount, but continued for a long time, may finally produce deleterious effects, even in a healthy person. If they are added to food the fact should be plainly stated on the label. The consumer has the right to know what he is buying. The label does not always tell the truth, however, as regards the quantity, for often the preservative is put in by a careless or ignorant workman and the amount is more or less guess-work.

There is one very efficient preservative which affects digestion in an indirect way, or to state it differently, while it does not affect some of the digestive ferments it does act upon the food, rendering it incapable of being digested. This is formaldehyde. Some years ago the writer carried on a series of experiments on the action of formaldehyde upon these ferments and the food materials. The results may be briefly summarized as follows:

Pepsin was dissolved in solutions of formaldehyde of different strengths and these allowed to stand. After varying intervals portions were removed and the digestive activity tested. It was found that pepsin was not affected, even after standing in a four per cent solution of formaldehyde for several weeks. Blood fibrin was used in these tests, being the most suitable material for testing the activity of pepsin; it is also a very good representative of our proteid food. Fibrin was allowed to stand in solutions of formaldehyde of varying strengths, and from time to time portions were tested with fresh pepsin solutions. It was found that fibrin, soaked in a solution of formaldehyde as dilute as one to one thousand, for a day, was hardened to such an extent that it could not be digested.

Analogous results were obtained with milk and with the milk curdling ferment rennin. The rennin was not affected, even after exposure for several weeks to a five per cent solution of formaldehyde. But milk, to which formaldehyde had been added in the proportion of one to one thousand and allowed to stand for a day, could not be coagulated with fresh rennin solution. Furthermore, such milk could not be digested with pepsin.

It is very easy to understand why so many bottle-fed infants have suffered and died in the past few years. It might be mentioned that formaldehyde is the principal ingredient of most of the embalming fluids on the market; it is also used extensively by pathologists and in museums because of its hardening and preserving action on proteid material.

One of the chief arguments against the use of chemical preservatives is that some food-stuffs that are unfit for consumption may, by the addition of a preservative to check further decomposition, be brought into apparently fit condition and then be put upon the market. Sodium benzoate in tomato pulp furnishes an excellent example of this. If the tomatoes are not worked up promptly into the final product—catsup, for instance—bacteria multiply rapidly and soon the material is in a more or less decomposed and decomposing condition; a little benzoate of soda is added to check further fermentation, and the mass in a more or less decayed condition is made into catsup. Last year the Tennessee Pure Food and Drugs Department examined twenty-eight samples of catsup; twenty-five of them showed a high bacterial count, indicating that they had been made from decayed material; but this material had received the benzoate treatment and then in varying stages of decomposition had been made into catsup. The labels on the bottles stated that they contained one-tenth of one per cent of benzoate of soda, but there was nothing to indicate what sort of material had been used; and further, of these twenty-five labeled as containing one-tenth of one per cent, fifteen had in reality a larger quantity—some having more than three times that amount.

Another example that might be mentioned is the use of sodium carbonate in milk, although this is probably not as common now as formerly. A little carbonate added to milk does not preserve it, but does neutralize the acid as rapidly as it is formed and thus keeps the milk tasting sweet. In the meantime decomposition has been going on right along, probably even more rapidly, because of the alkaline reaction favoring bacterial growth, until finally, after a few days, the milk may contain an enormous number of bacteria.

Many preservatives are on the market under fanciful names and bearing labels describing wonderful properties. They are quite analogous to some of the numerous "beauty preparations" sold, in that a small quantity of a cheap article is given a fancy name and wonderful properties are claimed for it, and it is sold for a high price. They usually bear statements that they are absolutely harmless and can not be detected by any chemical analysis. These statements are as false as the other claims made.

The number of preservatives in common use is limited to only a few. Some are better for one class of foods and others for other classes. When a sample is received for analysis the chemist usually knows that his search will be limited to probably not more than two or three substances as being the most likely to be found. In the case of milk, for instance, formaldehyde or borax would be expected; with sausage, sulphites or borax. It might be mentioned that a mixture of borax and boric acid is more efficient than either alone; they are frequently used together, and ordinarily are tested for in the same manner. Before the use of formaldehyde, which is comparatively recent, borax or boric acid was the most common preservative for milk.

In testing for preservatives the procedure depends upon circumstances. In some cases it is possible to apply the test directly to a portion of the sample; in others the preservative must be first separated from the other substances and isolated in more or less pure condition; while in still others a test may be made incidental to some other determination.

The testing of some foods for preservatives is often practicable in the home; however, too much reliance should not be placed upon the results unless the one making the tests has had some experience. It is usually not difficult to examine one of the ordinary articles of food for one of the common preservatives, when it is present in the amount generally used or absent altogether. But sometimes the preservative is present in small amount or is used in combination with other substances; there may be interfering substances present; and difficulties may arise during the manipulation, all of these complicating the work and tending to throw doubt upon the results.

Some Neglected Principles of Physiography

By A. H. PURDUE, State Geological Survey.

(*Abstract.*)

In this paper there are briefly considered some characteristics of entrenched meanders, the origin of limestone sinkholes, and (in the opinion of the speaker) some anticline valleys, and possibly of some transverse drainage.

Entrenched meanders, instead of commonly having the V-shaped form often attributed to them in the class-room, usually have unlike slopes on opposite sides of the stream in any given cross section, those on the outside of the curve being steep, and those on the inside more or less gradual. The reasons for this were given by the speaker.

Limestone sinkholes are seldom formed by the collapse of cavern roofs, as is generally supposed. Instead, most of them owe their existence to solution at the surface, by descending waters that are focused about openings, formed by jointing.

The common explanation of anticlinal valleys is that streams have gradually shifted from synclines to anticlines, the shifting having been invited by the excessive fracturing of the latter over the former. The writer believes that most anticlinal valleys have had a different history. It will be conceded that most folds had their inception while yet submerged. This granted, the first part of the folds to appear at sea level were the crests of the anticlines. Except at considerable depths, all the sedimentary material but that of calcareous nature was in the incoherent state at the time of elevation, and consequently was easily eroded. As soon as the anticlinal crests came within the effective force of the waves, they were thereby truncated. The rate of rise was greater than we are accustomed to admit, if the truncation did not for a long time equal the elevation. As the truncated material was shifted to the synclinal troughs, the whole process was a leveling

one. It is not unreasonable to suppose that many folded areas emerged as practically level plains, and that streams were at least as free to flow along anticlines as synclines.

In those cases where the rise of any anticline was rapid enough to overtake the erosive action of the waves, that action was still effective on the sides of the resulting islands. Added to this was the work of the subaerial agencies. On the whole, the direction of the resulting small streams was transverse to the anticlines. The anticlines did not everywhere emerge at a uniform rate, but appeared as rows of islands over each of which streams flowed radially. Consequently, some of the streams were, from the start, longitudinal to the direction of the anticlines, and others nearly so.

If at this stage the streams were still on incoherent material, the longitudinal ones had no particular advantage over the transverse ones; but if the indurated or partly indurated material had been reached, they had the special advantage of being able easily to seek out the soft beds and follow their strike. In the meantime, the material lapped off the sides by the waves and that washed into the sea by the streams was still filling up the adjacent synclines.

During the elevation, the synclines were occupied first by lagoons of salt, then brackish, and after complete emergence by those of fresh water. Even during the last stage they continued to be lines of decomposition until the lagoons dwindled into lakelets and finally disappeared. Meanwhile, the anticlines were lines of degradation, and it is not improbable that as many synclinal lakelets were drained into streams that followed anticlines as into those that followed synclines; and it seems not unreasonable to suppose that in the course of stream adjustment, as many have shifted from anticlines to synclines, as from synclines to anticlines, if, indeed, the former has not been the rule.

Folds are parallel to the old land areas from which the clastic material of their rocks was derived. In the addition of new land areas to old, the growth was often exogeneous. If a newly added area was folded, and the folds were leveled as above supposed, the streams from the old land gradually extended themselves over the new, and in general were at right angles to the folds. As the clastic sediments were yet incoherent and non-resistant, it seems probable that many streams so thoroughly established themselves across the folds as to maintain this course as the elevation continued and after the indurated rocks were reached. May it not be that this has been the history of some of our transverse drainage? This conception, while closely related to that of antecedent streams, is different because it contemplates folding that antedates the streams, while the latter contemplates a well established stream before folding takes place.

In cases where anticlinoria emerged, not contiguous to existing land areas, it seems wholly within the probabilities that many of the transverse streams assumed and maintained their courses across the minor folds of the limbs. It has occurred to the writer that possibly this has been the history of some of the numerous transverse streams in the Ouachita Mountain area of Arkansas.

Exhibit of Some Early Geologic Maps of Tennessee

By L. C. GLENN, Vanderbilt University.

In a few brief remarks the attention of the members of the Society was called to a collection of geological maps belonging to the School of Geology in Vanderbilt University and including practically all of the early geological maps that have been made of any part of Tennessee. Many of these maps are extremely rare today and possess much interest to the geologist in showing the conceptions early geologists had of the geology of the State, and how our knowledge of its geology has grown. Among the maps exhibited were those of Maclure, Owen, Marcou, Troost, Curry, Safford, Hitchcock, and Bradley.

Other Papers

Papers or addresses, manuscripts of which are not available for publication, were presented as follows at the meeting of November 28, 1913:

An address, relative to the aims and purposes of the Academy, was delivered at the opening session by the President, Prof. Watson Selvage, University of the South.

"A Natural Bridge of Tennessee in Process of Formation," by Mr. H. D. Miser, United States Geological Survey. Mr. Miser was introduced by Dr. A. H. Purdue. The paper is to be published in "Resources of Tennessee," Vol. IV, No. 4, 1914.

"A New Geological Map of Tennessee," by A. H. Purdue, State Geological Survey.

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TRANSACTIONS

of the

Tennessee Academy of Science

VOLUME TWO

January 1, 1914, to May 5, 1917

Issued November 15, 1917, Nashville, Tenn.

TRANSACTIONS

of the

Tennessee Academy of Science

VOLUME TWO

January 1, 1914, to May 5, 1917

Williams Printing Company, Nashville

CONTENTS

CONSTITUTION

[As adopted March 9, 1912, and amended at subsequent times.]

ARTICLE I.

NAME AND OBJECTS.

SECTION 1. This Association shall be called the Tennessee Academy of Science.

SEC. 2. The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science; to promote intercourse between persons engaged in scientific work, especially in Tennessee; to assist by investigation and discussion in developing and making known the material, educational, and other resources and riches of the State; to arrange and prepare for publication such reports of investigations and discussions as may further the aims and objects of the Academy as set forth in these articles.

ARTICLE II.

MEMBERSHIP.

SECTION 1. The membership of the Academy shall consist of active, associate and honorary members.

SEC. 2. *Active Members*—Any white person interested or engaged in any department of scientific work or original research in any department of science shall be eligible to active membership in the Academy. Active members only shall have the right to vote and to hold office.

SEC. 3. *Associate Members*—Any white undergraduate college student, who is interested in any department of scientific work, may become an associate member; also, any active member on removing from the State may, on his request, be transferred to this associate membership class.

SEC. 4. *Honorary Membership*—Any white person who has attained prominence in any department of science, on the recommendation of the Executive Committee, may be elected an honorary member at any regular meeting by a three-fourths vote of the active members present. No more than three honorary members shall be elected in any year.

SEC. 5. *Method of Election*—To become an active or associate member, it shall be necessary, first, that the candidate make application in writing, indorsed by two active or honorary members; second, that he receive a majority vote of the Executive Committee; and third, that he pay the annual dues for the first year.

ARTICLE III.

OFFICERS.

SECTION 1. The officers of the Academy shall consist of a President, Vice President, Secretary-Treasurer, and Editor, who shall be elected by ballot at the annual meeting and shall hold office one year, or until their successors are installed. They shall perform the duties usually pertaining to their respective offices.

Sec. 2. The Executive Committee shall consist of the officers of the Academy, together with two other members, who shall be appointed by the President. It shall be the duty of the Executive Committee to approve or reject candidates for election as members, to prepare the programs, and have charge of the arrangements for all meetings.

ARTICLE IV.

PUBLICATIONS.

The official publication of the Academy shall be called *Transactions of the Tennessee Academy of Science*, and shall be published as occasion demands.

The Executive Committee shall have authority to make arrangements for the publication of a journal, provided that no more than one-half of the annual dues be used for that purpose.

ARTICLE V.

MEETINGS.

The annual meeting shall be held on the Friday following Thanksgiving Day, at such place as the Executive Committee shall determine. Special meetings may be held at such times and places as the Executive Committee shall determine.

ARTICLE VI.

DUES.

The annual dues of the active members shall be $2.00 and of associate members $1.00, which shall entitle them to receive the Transactions and other publications of the Academy. Honorary members shall not be required to pay dues, but any honorary member desiring to receive the publications of the Academy shall pay $2.00 per annum.

ARTICLE VII.

AMENDMENTS.

This constitution may be altered or amended at any annual meeting by a three-fourths majority of the members attending, due notice of such change having been given fifteen days in advance.

BY-LAWS

[As adopted March 9, 1912, and amended at subsequent times.]

1. On motion, any special department of science shall be assigned to a curator, whose duty it shall be, with the assistance of the other members interested in the same department, to endeavor to advance knowledge in that particular department. Each curator shall report at such time and place as the Academy shall direct. These reports shall include a brief summary of the progress of the department during the year preceding the presentation of the report.

2. The retiring President shall deliver a public address on the Friday evening of the annual meeting.

3. The Editor shall attend to the securing of proper newspaper reports of the meetings, assist the Secretary, and edit all publications of the Academy.

4. No meeting of the Academy shall be held without a notice of the same having been sent to the address of each member at least fifteen days before such meeting.

5. No bill against the Academy shall be paid without an order signed by the President and countersigned by the Secretary.

6. Members who shall allow their dues to remain unpaid for two years, having been annually notified of their arrearages by the Treasurer, shall have their names stricken from the roll.

7. Twelve members shall constitute a quorum for transaction of business.

OFFICERS FOR EACH YEAR

1912.

President, Chas. H. Gordon, University of Tennessee, Knoxville.
Vice President, J. I. D. Hinds, Cumberland University, Lebanon.
Secretary, Wilbur A. Nelson, State Geological Survey, Nashville.
Treasurer, Samuel M. Barton, University of the South, Sewanee.
Editor, E. S. Reynolds, University of Tennessee, Knoxville.

1913.

President, Watson Selvage, University of the South, Sewanee.
Vice President, G. W. Dyer, Vanderbilt University, Nashville.
Secretary, Wilbur A. Nelson, State Geological Survey, Nashville.
Treasurer, Samuel M. Barton, University of the South, Sewanee.
Editor, R. M. Ogden, University of Tennessee, Knoxville.

1914.

President, L. C. Glenn, Vanderbilt University, Nashville.
Vice President, W. E. Myer, Carthage.
Secretary, Roscoe Nunn, U. S. Weather Bureau, Nashville.
Treasurer, A. Belcher, Middle Tennessee Normal School, Murfreesboro.
Editor, Jas. A. Lyon, Southwestern Presbyterian University, Clarksville.

1915.

President, W. E. Myer, Carthage.
Vice President, P. H. Manning, West Tennessee Normal School, Memphis.
Secretary, Roscoe Nunn, U. S. Weather Bureau, Nashville.
Treasurer, A. Belcher, Middle Tennessee Normal School, Murfreesboro.
Editor, Jas. A. Lyon, Southwestern Presbyterian University, Clarksville.

1916.

President, Samuel M. Bain, University of Tennessee, Knoxville.
Vice President, Samuel M. Barton, University of the South, Sewanee.
Secretary, Roscoe Nunn, U. S. Weather Bureau, Nashville.
Treasurer, A. Belcher, Middle Tennessee Normal School, Murfreesboro.
Editor, A. H. Purdue, State Geological Survey, Nashville.

1917.

President, Samuel M. Barton, University of the South, Sewanee.
Vice President, A. Belcher, Middle Tennessee Normal School, Murfreesboro.
Secretary-Treasurer, Roscoe Nunn, U. S. Weather Bureau, Nashville.
Editor, A. H. Purdue, State Geological Survey, Nashville.

MEMBERS

(Revised November 1, 1917.)

HONORARY.

Ashley, Geo. H................U. S. Geological Survey, Washington, D.C.

ACTIVE.

Ayres, Brown ....University of Tennessee, Knoxville.
Bailey, Thomas L...............University of the South, Sewanee.
Bain, Samuel M.................University of Tennessee, Knoxville.
Barton, Samuel M..............University of the South, Sewanee.
Belcher, Archibald ....Middle Tennessee Normal School Murfreesboro.
Berkey, D. W....................University of the South, Sewanee.
Black, Ralph P..................University of the South, Sewanee.
Blake, V. W.......................Hume-Fogg High School, Nashville.
Bowers, Paul C..................State Geological Survey, Nashville.
Bowrom, Wm. M.............The Tradesman, Chattanooga.
Brown, C. B.......................Sweetwater.
Brown, C. S.......................Vanderbilt University, Nashville.
Buchanan, H. E.................University of Tennessee, Knoxville.
Cole, W. R........................Napier Iron Works, Nashville.
Conover, Miss Margaret C.....University of Tennessee, Knoxville.
Converse, Miss Ellen C....Hixson High School, Hixson.
Converse, J. E...................Crossville.
Daniel, Sinclair ....Clarksville.
Davis, Roy B......................University of the South, Sewanee.
Dresslar, F. B....................Peabody College for Teachers, Nashville.
Eastman, A. Sherman......University of the South, Sewanee.
Ewing, S. Cecil.................Nashville.
Faulkner, Aubrey V.........Jacksboro.
Glenn, L. C........................Vanderbilt University, Nashville.
Gordon, C. H.....................University of Tennessee, Knoxville.
Hall, Wm. B.......................320 Tremont Avenue, Selma, Ala.
Hinds, J. I. D....................Castle Heights School, Lebanon.
Hollinshead, W. H...........Vanderbilt University, Nashville.
Holt, R. B..........................Tennessee College, Murfreesboro.

Hooper, Frank F.............University of Chattanooga, Chattanooga.
Howser, W. D....................State Game Warden, Nashville.
Isbell, J. E..........................Madison.
King, Miss Jeanette M....Middle Tennessee Normal School, Murfreesboro.
Lee, Victor P.......................Nashville.
Leonard, N. C....................328 Doctors' Building, Nashville.
Lewis, Henry W................Nashville.
Lipscomb, H. S..................Hume-Fogg High School, Nashville.
Lyon, Scott C....................Southwestern Presbyterian University, Clarksville.
McGill, John T..................Vanderbilt University, Nashville.
McKenzie F. A..................Fisk University, Nashville.
Maddox, R. S....................State Forester, Nashville.
Manning, P. H ....West Tennessee Normal School, Memphis.
Mason, I. P........................Alabama Presbyterian College, Anniston, Ala.
Matteson, Miss Emma B..Peabody College for Teachers, Nashville.
Morgan, H. A....................University of Tennessee, Knoxville.
Myer, W. E........................Carthage.
Neel, L. R...........................Southern Agriculturist, Nashville.
Nelson, Wilbur A.............Cartersville, Ga.
Nicholson, J. W. B...........McCann School, Nashville.
Nunn, Roscoe ....U. S. Weather Bureau, Nashville.
Owen, Louis H..................Nashville.
Owens, James N...............High School, Decherd.
Paris, John T.....................165 Second Avenue, N., Nashville.
Parkins, A. E.....................Peabody College for Teachers, Nashville.
Peyton, John Howe ....N. C. & St. L. Railway, Nashville.
Purdue, A. H......................State Geologist, Nashville.
Roberts, E. L......................407 Jackson Building, Nashville.
Shaver, Jesse M.................Peabody College for Teachers, Nashville.
Smith, Miss Delle D.........East Tennessee Normal School, Johnson City.
Spitz, Herman ....Doctors' Building, Nashville.
Walker, Robert C............University of the South, Sewanee.
Walker, Robert S.............Southern Fruit Grower, Chattanooga.
Webb, A. C.........................309 Wilburn Avenue, Nashville.
Whitmore, John.................University of the South, Sewanee.
Wilson, Latimer J.............1405 Gartland Avenue, Nashville.

RECORD

(From January 1, 1914, to the meeting of May 4-5, 1917, inclusive.)

Meeting of April 10, 1914.

This meeting was held at Hume-Fogg High School, Nashville, President L. C. Glenn presiding. A part of the afternoon program was in the nature of a joint session with the Middle Tennessee Educational Association. The program of papers was as follows:

Some Observations on Smoke Injury to Timber in the Ducktown Region.
Samuel M. Bain, University of Tennessee.

The Work of the State Game Warden.
W. D. Howser, State Game Warden.

Some Observations and Experiments with the Epeira, or Garden Spider.
Robert S. Walker, Editor Southern Fruit Grower.

Animal Life in Early Tennessee.
Henry W. Lewis, Nashville, Tenn.

Science in the High School.
P. H. Manning, West Tennessee Normal School.

The Claims and Place of Biology in Education.
R. I. Raymond, University of the South.

Some Milestones in the History of Electrical Science.
Archibald Belcher, Middle Tennessee Normal School.

Hog Cholera Based on Serum Treatment.
G. R. White, State Veterinarian.

Organic Evolution.
J. H. Yoe, Vanderbilt University.

The Relations of the Sciences to the Teaching of Agriculture.
Verd Peterson, Middle Tennessee Normal School.

Meeting of November 27, 1914.

The meeting was held at Carnegie Library Hall, Nashville, President L. C. Glenn presiding. The program of papers was as follows:

Pearl Fisheries of Tennessee (illustrated).
W. E. Myer, Carthage, Tenn.

Economic Ophiology of Tennessee.
HENRY W. LEWIS, Nashville, Tenn.

Galls and Gall-Producing Insects.
ROBERT S. WALKER, Editor Southern Fruit Grower.
(Published in "Country Life in America", September, 1916.)

Some Maligned Birds.
DIXON MERRITT, Nashville, Tenn.

Some Link-Motions—How to Draw a Straight Line (illustrated).
SAMUEL M. BARTON, University of the South.

Some Chert Concretions Near Clarksville, Tenn. (illustrated).
JAMES A. LYON, Southwestern Presbyterian University.

Researches in Disease Resistance in Red Clover; Preliminary Report (illustrated).
SAMUEL M. BAIN, University of Tennessee.

Some Personal Reminiscences of the Early History of the Telephone.
BROWN AYRES, University of Tennessee.

Comment on Some Occurrences of Phosphate in Tennessee.
JOHN DANIEL, Vanderbilt University.

Natural Meadows of the Cumberland Plateau.
L. R. NEEL, Editor Southern Agriculturist.

(a) Observations of Mars and Jupiter During the 1914 Opposition of These Planets (illustrated); (b) A Brief Account of the Progress in Color Photography (illustrated).
LATIMER J. WILSON, Nashville, Tenn.

Annual Address of the President: The Physiography of Tennessee in Relation to the State's Development.
L. C. GLENN, Vanderbilt University.
(Published in "Resources of Tennessee", Vol. V, No. 2.)

MEETING OF NOVEMBER 26, 1915.

The meeting was held at Peabody College for Teachers, Nashville, President W. E. Myer presiding. The program of papers was as follows:

Why Potteries Should Be Established in West Tennessee.
WILBUR A. NELSON, Nashville, Tenn.

Preservation of Our Forests.
R. S. MADDOX, State Forester.

Cause of the Stylolitic Structure in the Tennessee Marble.
C. H. Gordon, University of Tennessee.

Phosphate Rocks of Johnson County, Tenn.
Olaf P. Jenkins, State Geological Survey.
(Published in "Resources of Tennessee", Vol. VI, No. 2.)

The Evolution of Mississippi River Craft as Influenced by Geographic Conditions.
Charles C. Colby, Peabody College for Teachers.

Recent Results in Mathematical Astronomy.
H. E. Buchanan, University of Tennessee.

(a) An Irrigation Slide for Prolonged Observation of Living Aquatics; (b) A Simple Device for Aerating Aquaria.
Samuel M. Bain, University of Tennessee.

Guessing as Influenced by Odd Numbers.
F. B. Dresslar, Peabody College for Teachers.

Nature and Origin of the Holston Marble Formation in East Tennessee.
C. H. Gordon, University of Tennessee.

Memorial Sketches of Deceased Members:
(a) Dr. William L. Dudley.
L. C. Glenn, Vanderbilt University.

(b) Dr. James A. Lyon.
J. I. D. Hinds, Castle Heights School.

(c) Mr. James H. Baird.
S. Cecil Ewing, Nashville, Tenn.

Annual Address of the President: The Probable Origin of the American Indian.
W. E. Myer, Carthage, Tenn.

Meeting of December 1, 1916.

The meeting was held at Peabody College for Teachers, Nashville, President Samuel M. Bain presiding. The program of papers was as follows:

The Development of Transportation on the Great Lakes (illustrated).
A. E. Parkins, Peabody College for Teachers.

An Apparatus for Moisture Determination (illustrated).
A. S. Eastman, University of the South.

Chemists' Present Opportunities and Duties.
J. I. D. Hinds, Castle Heights School.

Some Practical Applications of Bacteriological Research (illustrated).
Herman Spitz, Nashville, Tenn.

The *Raison D'etre* of the Tennessee Academy of Science.
Samuel M. Barton, University of the South.

The Origin of Reelfoot Lake.
A. H. Purdue, State Geological Survey.

Following the Compass Across Sahara (illustrated).
D. W. Berky, University of the South.

James M. Safford; Biographical Sketch and Bibliography of His Works.
John T. McGill, Vanderbilt University.

West Indian Hurricanes; Their Origin, Movement, and Extent (illustrated).
Roscoe Nunn, U. S. Weather Bureau.
(Discussed by R. S. Maddox, State Forester.)

Annual Address of the President: The Interrelation of Plant and Animal Pathology (illustrated).
Samuel M. Bain, University of Tennessee.

Meeting of May 4-5, 1917.

The meeting was held at the University of the South, Sewanee, and was the eighth meeting (third spring meeting) of the Academy. President Samuel M. Barton presided. The Academy was welcomed in a brief address by the Vice Chancellor of the University of the South, Bishop Knight. The program of papers was as follows:

Some Features of the Natural History of the Sewanee District:

1. The Forests of Sewanee (illustrated).
   R. S. Maddox, State Forester.
2. The Climate of Sewanee.
   Roscoe Nunn, U. S. Weather Bureau.
3. The Cumberland Plateau as a Crop-Producing Section.
   J. E. Converse, Crossville, Tenn.
4. Ferns Found in the Vicinity of Sewanee (illustrated).
   John T. McGill, Vanderbilt University.

Wild Fruits of Tennessee.
Robert S. Walker, Editor Southern Fruit Grower.

Some Flowers of Middle Tennessee.
Jesse M. Shaver, Peabody College for Teachers.

Yellowstone Park (illustrated).
Geo. H. Ashley, U. S. Geological Survey.

On May 5th the members of the Academy in attendance, led by President Barton, and accompanied by a number of friends, made an excursion to Wonder Cave, near Monteagle, Tenn.

WORK OF STATE GAME WARDEN*

BY W. D. HOWSER, STATE GAME WARDEN.

[Read before the Academy, April 10, 1914.]

The Game Law of this State prohibits the killing at all times of non-game birds, and the destruction of their nests and eggs. It prohibits the killing of game birds, except at certain seasons of the year, and protects their nests and eggs at all seasons of the year.

It prohibits the use of traps, snare, coop net, bird lime, deer lick, turkey blind or pen, and medicated or poisonous food to kill or capture any game or game bird; prohibits the use of swivel or punt gun, or any fire, light or other contrivance to attract, deceive or blind any game or game bird, except that decoys may be used in shooting ducks, geese or brant.

It prohibits shooting after sunset or before sunrise, or the burning of powder or other inflammable substance upon the feeding or roosting grounds of ducks, geese or other water fowls; prohibits shooting on Sunday or upon the public highway. It limits the bag to fifty ducks or thirty quail, or other birds, and prohibits the shipment of quail and robins.

The fish law of this State prohibits the taking or catching of fish by any method or device except with hook or line or trot lines, except adjacent land owners may secure permits to use baskets to take fish for their consumption. It also provides that professional fishermen may secure license to fish with certain devices in the three large rivers of the State. It prohibits the obstruction of any stream so as to prevent the free passage of fish, and makes the unlawful use of seines, nets, traps or other devices a public nuisance. It prohibits the exportation of game fish, and prohibits the sale of game fish during the months of April and May. It prohibits the use of fish lime or any kind of poison, and provides a penalty of $200.00 and imprisonment for the use of dynamite. It makes it a misdemeanor

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*This paper was read April 10, 1914. Since that time a number of changes have been made in the laws for the protection of game and fish in Tennessee.—Ed.

for anyone to pollute any of the streams of the State, and provides for the arrest and punishment of all violators of the law.

It is the duty of the State Game Warden to see that these laws are properly enforced, and to appoint special game wardens to assist him in so doing. It is, also, the duty of the State Game Warden to have charge and control of Reelfoot Lake, and the fishing and hunting privileges belonging thereto. It is not only the duty of the State Game Warden to see that these laws are enforced, but it is necessary for him to collect the money to pay for the work done in this direction.

A license is required of professional fishermen, game dealers, resident and non-resident shooters and market hunters. A license is required of professional fishermen, etc., and the moneys derived from the sale of these licenses, and the fines collected for violations of the Game, Fish and Forestry Laws, are paid into the hands of the State Game Warden, and that is the only means he has of securing money with which to run the Department of Game, Fish and Forestry.

As I have just stated, it is the duty of the State Game Warden to appoint special wardens in different parts of the State, but the only provision for the paying of the special wardens is that they secure one-half of the fines collected by them for the violations of the law.

The forestry laws of this State prohibit setting fire to any forest belonging to the State, to the United States, or to any person, or to wilfully, negligently and maliciously set on fire any woods, grass-lands, etc., by any means, whereby the property of another is injured. It prohibits the wanton injury of timber or any forest tree belonging to another, and requires railroads to protect their right of ways from fires that might be communicated to adjacent woodland.

The enforcement of the forestry laws is also made the duty of the State Game Warden; the State, however, has made no provision of any kind by which the State Warden can secure funds to properly enforce the forestry laws of the State.

These are some of the duties of the State Game Warden, but in my opinion, the greatest work for the Game Warden to accomplish at this time would be to secure the active co-operation of all those citizens of the State who are in favor of the protection of wild life, and the conservation of our game, our fish and our forests.

There has been, and is, a prejudice against this Department of the State Government. Many men believe that they ought to have the right to kill wild animals or birds at any time, and in any way that they desire to do so; many men believe that the Game and Fish laws should be enforced against all the other people in the State, but not against themselves, while others believe that no laws should be enforced, and especially a law that would prohibit them from throwing a stick of dynamite in a creek, pond or river, and destroying millions of fish, just because they want to.

There are a great many men in the State, good citizens, men who would love to see the laws enforced, but who are afraid to make complaint, because they believe that the men who will wantonly destroy the birds and the fish and the forests, would not hesitate to destroy houses and stock—lives. They are, therefore, afraid to report violations of the Game, Fish and Forestry laws, and it is impossible for the State Game Warden and the special wardens to enforce the law, unless the violations are reported to the department, and men are willing to become witnesses against the offenders.

It is necessary, also, for the State Game Warden to overcome a prejudice against the department, caused by the peculiar organization of the department. Many men who violate the law, go to the civil officers and protest against any punishment, or the assessment of any fines against them, because the fines are paid into the department, and many of the civil officers absolutely refuse to have anything to do with the enforcement of the Game, Fish and Forestry laws.

In some parts of the State, these laws are very unpopular, and the civil officers refuse to help prosecute the violations of the law. However, their refusal is not wholly the fault of the officers, because heretofore, the department has not asked, and therefore, has not secured, the support of these officers.

It seems to me, therefore, that one of the greatest works for the State Game Warden is to secure the active and hearty co-operation of all the civil officers of this State. Every sheriff in this State ought to be ex-officio a Game Warden for his county, and every deputy sheriff ought to be ex-officio a deputy game warden. Every constable ought to be a special warden for his district, and the sheriffs and their deputies and the constables should be given to understand that it is as much their duty to see that offenders against these laws are punished as the offenders against other laws.

The present State Game Warden has asked and received the hearty co-operation of a number of sheriffs in this State, but not all of them. In some sections the sheriffs have absolutely refused to have anything to do with the enforcement of these laws, and this being an election year, and many of the sheriffs and constables being candidates for re-election, and the laws being unpopular in many sections of the State, the right-thinking man can hardly blame these officers for refusing to act as game wardens at this time.

The game laws, however, can never be enforced in this State until the department has the active co-operation of all officers, and it is my intention to make every sheriff in this State a game warden after the August election, and every constable a special warden in his district.

I believe that the State Game Warden has been given too much power in some instances and too little in others. I believe that the laws should be so amended as to give the grand juries of the State inquisitorial power in all cases of the violation of the Game, Fish and Forestry laws, and that all money derived from fines for the violations of these laws should be covered into the State Treasury, as are the fines from all other violations of the law, and placed to the credit of the Department of Game, Fish and Forestry, but in no case should the office of the State Game Warden depend upon the fees collected by the wardens for the moneys necessary to carry on the work of the department.

In fact, our Game, Fish and Forestry laws should be rewritten from beginning to end, and so written as to make, as I have above suggested, their enforcement as much the duty of the officers of the law in all the counties of the State as is the enforcement of any other law.

Some of you men have seen the passenger pigeon, millions of them. How long has it been since you saw one of them?

Last year a number of men baited a field for doves in one of our sister States near our border, called in their friends and killed more than 6,000 doves in one day. Last year in this State the sportsmen began shooting doves on August 1st. At that time many of the young doves were unable to fly, and the killing of the mother dove left the little ones in the nest to starve. I wonder how long it will be, if these practices are not stopped, before the cooing of the dove will be as strange to the ears of the boys and girls of this State as is the flight of the passenger pigeons to the man of today.

Many of you have seen thousands and thousands of robins in one roost; some of you can remember now a robin roost. There are three or four that I know of today, and the vandals visit these roosts now as they did years ago, and kill and destroy as many of them as possible. This is a misdemeanor, and our farmers, except the vandals among them, desire that the law be enforced, but they are afraid to give the information necessary to convict the offenders. I wonder how long it will be until a robin roost will be a thing of the past.

I was talking the other day to one of the U. S. Government Inspectors, and he told me that he visited a camp in Arkansas, a camp of duck hunters. Just behind the camp, in a ravine, he and his assistant counted more than 600 ducks that had been thrown in the ravine to rot. The hunters would kill and bring to camp as many ducks as possible, select two or three of them to eat, and throw the rest of them in the ravine to rot, and some of the natives would visit the ravine and gather up the ducks in their wagons and feed them to their hogs. In this State we have a law permitting the killing of fifty ducks per day, and many hunters kill their limit. I wonder how long it will be, if these practices are not stopped, until the whir of the wings of the teel and black jack will be heard no longer along the waters and lakes of Tennessee.

The other day the State Game Warden of this State visited a stream that had been dynamited, and he and the man who was with him counted more than 2,000 little fish that had been killed by the explosion of the dynamite in the stream. It was impossible for him to secure a statement from any man that would convict the party who violated the law by dynamiting the stream.

In the spring of the year, as is well known to all of you, the game fish, as well as the non-game fish, go up the streams to spawn. There are some men in almost all localities who know the habits of fish, and taking advantage of this knowledge, set traps and nets to catch the fish as they go up to spawn, and this not only destroys the fish, but destroys their eggs, also.

In some counties of the State we have local laws permitting residents of the county to gig, and the other day I saw one of those people with a string of sixteen trout that had been gigged off their nests or beds. I wonder how long it will be, if these practices are not stopped, until the trout will be as rare in our streams as is the passenger pigeon in our air. I wonder how long it will be until the farmers of this State recognize the fact that a man who wantonly destroys the fish in the streams of the State is an enemy of the community and of the State. I do not know.

We need an educational campaign all along the lines that I have mentioned, and it will require the active co-operation of every man who loves birds, who enjoys fishing, and who recognizes the economic value of the birds and fish, to accomplish anything in a campaign of education. The children in our public schools ought to be taught the value of wild life. I believe that one way to start this campaign is to ask that we have a Bird Day in every school in this State, and that on that day some prominent citizen in the district read the law, others tell stories about the birds, and others give an outline of the work the birds do for man, and thus, by getting the boys and girls interested in the birds, create a sentiment that will compel obedience to the Game Laws of the State.

I believe that it would be a good idea for this society to send a committee to the Board of Education of this State, asking that one day in each school year be set aside as Bird Day.

The Middle Tennessee Teachers' Association is now in session in this city. Would it not be a good beginning for us to take this matter up at this meeting of the teachers of Middle Tennessee and get their co-operation? If we could do so, and I could prevail upon the members of this society to give me their assistance at this time, I would feel that I had done some material work as the head of the Department of Game, Fish and Forestry of Tennessee.

PEARL FISHERIES OF TENNESSEE

BY W. E. MYER, CARTHAGE, TENN.

[Read before the Academy, November 27, 1914.]

That you may more fully appreciate Tennessee pearls and the fascination of the pearl fishery in this State allow me to call your attention to the fact that fine, perfect, Tennessee pearls are worth more than the highest grade diamonds of same size. The chance of finding a pearl worth anywhere from one hundred dollars to two thousand dollars in the very next mussel opened draws men to the river and holds them there, even after weeks of poor success, or even absolute failure. I knew one farmer who went to the river to water his horse at noon, and, while the horse was drinking, idly picked up a mussel lying in easy reach. He opened the mussel and found a pearl for which I paid him $190.00. This started him to putting in all his spare time. For a year he worked at pearling whenever his farm work would permit and never found another pearl of any value. This, of course, is an exceptional case and is given only to show how the eternal hope of good luck abides in man's breast.

In these later days the pearlers find it is safer and more businesslike to work in partnership with four or five others. This body of, say, five men put all their findings together and divide the proceeds equally. By saving and selling both the shells and pearls they are reasonably sure of making some two dollars each per day, if they work not less than two weeks at it.

Cumberland and Clinch Pearls.

While all the rivers in the State produce more or less pearls, the Cumberland and Clinch are amongst the great pearl-producing waters of the world. I say "are," but, unless some sane restraint is speedily thrown around the heedless total working out and total destruction of every mussel in each mussel bed and leaving no living mussels to reproduce the race, we are going soon to have to say "were". Already the production has fallen off to nothing in many formerly rich pearling grounds, because no mussels were left to reproduce.

The reason so few Tennessee people know much about these beautiful gems from their own rivers is because the great majority of the pearls are sent direct to New York for sale, as New York is the great pearl market of the United States.

The Beauty of Pearls from Our Clear Streams.

The beauty, and therefore value, of a pearl is greatly increased by being produced by mussels in clear water. For this reason the pearls from the clear streams of our Tennessee Highlands are famous for their beauty and value.

The waters of each section of the United States contain different elements in solution. These elements give a different appearance to the pearls from those sections. Pearls from our clear, pure, highland streams are a beautiful white; those from Wisconsin, whose waters have a slight impregnation of copper, are a beautiful green; those from red, sandy streams being rusty-reddish, or sometimes a beautiful bronze. An expert can look at an unknown pearl and tell from what section it came.

I am showing you herewith some typical pearls from the Cumberland and Caney Fork rivers. I am also showing you typical pearls from all the other pearl-producing sections, not only of the United States but from all the great pearl waters on the globe—pearls from the Arabian Sea, the Coast of Ceylon, coast of North Australia, Venezuela and Japan—white pearls, rare black pearls, bronze pearls, pink pearls, green pearls.

History of Pearl Industry in Tennessee.

Pearls had been found now and then in our rivers since the white men first came here. No one appeared to realize their value or possibilities. Nothing was done to develop the industry until about 1876. About this year a fisherman on Caney Fork River, near Lancaster, found a magnificent pearl which, after going from one less posted man to another a little better posted, and so on through several hands, is said to have brought in New York about \$2,000.00, and was probably worth, from the best descriptions I have been able to get of it, not less than \$10,000.00. This set the people to looking for pearls and soon hundreds were making good money in the then unworked mussel beds of that section.

I show you herewith a lantern slide showing the stretch of Caney Fork River where the first pearl was found. This beautiful stretch of river is the worthy setting for the birthplace of Tennessee pearl industry.

I will first give you some lantern slides which will show you the way pearlers gathered mussels when the industry first began. These slides are historic, from the fact they are from photos made at that beginning period. They show, not only the method of gathering and opening the mussels, but, if you will carefully study the men shown engaged in the work, you will see all classes are represented. In this group at work pearling you will find bankers, merchants, lawyers, doctors and fishermen. Not that these men gave up their ordinary vocations and went pearling for a livelihood, but every one was excited and every one took a try at it in idle moments. One of the men in this group later went to New York, where he became one of the large pearl dealers of the world. You will see, they waded out into the shallow waters and either grabbled up the mussels with their hands, or spaded them up with the heavy iron forks shown herewith. At this time no attempt was made to gather in water over a man's head. In fact none of the pearlers knew mussels existed in deep waters. I also present slides showing how the mussels are gathered at the present time. At the present time all the mussels have been gathered from the shallow waters, and the pearler gathers them by drags or dredges from deep waters. The drag is composed of an iron bar, about five feet long, to which short pieces of cord with wire prongs are attached. This is dragged along the bottom and when one of the cords or wire prongs touches the open mussel, the mussel instantly closes, for self-protection as he hopes, on the cord and, thus clinging, is brought to the surface and taken off by the pearler.

The dredge is a heavy apparatus armed with huge teeth in front and a heavy bag behind. The dredge is drawn along the bottom by gasoline launches. The spike-like teeth are driven into the bottom and drag out and bag the mussel.

At the beginning of the pearl industry no one dreamed the shells had any value. But later there came to this country a big, tall, rawboned, bespectacled German named Boeple. He, with German thoroughness, made a personal investigation of many of our pearl rivers.

On the Cumberland he did not content himself with beginning where pearls were then being found. Neither did he content himself with beginning at the head of navigation as the most determined Americans would have done. Dressed in a uniform of serviceable khaki, at a time when khaki was unknown in this country, he started from up in the feud country of the Pine Mountains of Kentucky, where the Cumberland was about the size of a large spring branch. He walked down it to the falls in Whitley County; there built a rough plank canoe and continued down to the mouth of the Cumberland near Paducah, something near a thousand-mile exploration trip. Boeple came to see me at Carthage. He told me that he had found eighty different species of mussels in Cumberland River, and that there was a fortune in working up the shells into pearl buttons. He urged me to go in with him and start a button factory. No! Not I! I was too smart to be drawn into the iridescent meshes of a dreamer! He went on to Muscatine, Iowa. Finally, finding he could get no one to go in with him and furnish the needed capital he began making buttons out of mussel shells in a little tumbledown shanty in Muscatine. They laughed at him but watched him. Boeple failed because of lack of money. One of the shrewd business men of Muscatine saw the possibilities and established a factory that made him a fortune. Soon prosperous factories sprang up in many places. Boeple remained poor. But, when he died, Iowa erected a splendid monument in his memory.

The Origin of the Pearl.

The cause or origin of the pearl is always a question of great interest. The great majority of pearls have been caused, either by some irritating substance like a grain of sand getting imbedded in the mussel and becoming a source of irritation, or by the egg of a small parasite, which preys upon mussels, becoming a source of irritation. In either case, nature gives the mussel the automatic power to secrete this smooth pearly substance around the irritating object and thus reduce the trouble. The vast majority of pearls are caused by the egg of the parasite.

Japanese Culture Pearls.

The Japanese learned this secret of the origin of the pearl many hundreds of years ago. They have ingeniously taken advantage of it to cause the formation of immense quantities of "culture pearls", as they are called. They insert into the shell of the pearl oyster small, half-round, smooth objects and fasten them to the shell with cement. In the course of five or six years these are so coated with pearl as to have all the outward appearance of genuine pearl. Only an expert can detect the difference. I show you a sample of these Japanese culture pearls in the original shell.

Specimens of Jewelry Made from Tennessee Pearls.

I will show you now some jewelry made from Cumberland River pearls. I am sure that the beauty of these rings and pins will awaken all the lurking savage in you. Pearls have been found and admired and worn by savage man in every age and every part of the world where mollusks are found.

The World's Greatest Find of Pearls.

De Soto, in his celebrated and ill-fated march through Georgia, gave the Indians a very creditable imitation of what Sherman's later march through Georgia was to be. You know what Sherman called war. It is said that the Indians entertained for De Soto the same tender affection that the later Georgians entertain for Sherman.

Be that as it may, or as it most likely was, De Soto found in one of the temple houses of a Georgia Indian town the enormous quantity of two bushels of pearls. Never before or since in the history of the world has such enormous booty been found. The value of this booty must have amounted, at present prices, to hundreds of millions of dollars. To relieve the Indians of the care and worry of this enormous treasure, he kindly took it with him. He also very considerately opened many of the graves of their great men and took the gems buried there. This is probably the pot calling the kettle black, as the speaker has done a great deal of this same grave work, as you will see later on. De Soto was never able to get his pearls to market. As the trials of De Soto's men increased, they threw away all useless impedimenta. Then De Soto, hoping to get a better spirit into his men, divided this immense pearl booty and gave to each his share, which was about one pint. This was enough to make each man rich, if he could only get them home; but, as their troubles increased, they gradually threw away their pearls.

Pearls from Castalian Springs Mound.

I show you herewith several beautiful pearls taken by me from the grave of an Indian in a great burial mound at Castalian Springs, Tennessee. These pearls were fitted around the edge of a beautiful sacred gorget, which he wore suspended from his neck. I also show the gorget. Imagine this beautiful engraved shell gorget, with its rich roseate pink edge studded with these lustrous pearls. This pearl-studded gorget is probably the finest article of adornment ever taken from the grave of a mound builder.

I spent two summers exploring this old mound-builder town at Castalian Springs. Its story is very interesting. No scientist ever had the good fortune to discover and explore more interesting remains of the unknown past, situated in one of the most beautiful sections of the South, inhabited by such splendidly hospitable people.

The Imperial Pearl Set of Empress Eugenie.

I show you herewith one of the most beautiful specimens of artistic pearl jewelry human ingenuity has ever produced. It is the Imperial Pearl Set of Empress Eugenie. It contains over one thousand oriental pearls. Its value is about $20,000.00. The mounting and arrangement of these pearls required all the time of one man for over three months. This historic pearl set of the Empress Eugenie is the property of my brother, Mr. Herman Myer, of New York City. Many of the other pearls and shells I have shown you also belong to him. He helped me by arranging the display cases and giving me much needed information. My hearty thanks are due him.

This quaint pearl set, in its old and worn case, has a history in which is interwoven some of the brightest and some of the saddest things of the last hundred years. Eugenie, whose mother was a citizen of the United States and whose father was a blue-blooded grandee of old Spain, married the Emperor Napoleon III. It was one of the few royal marriages for love. Great pressure was brought on Napoleon not to marry her, but to marry a woman of a reigning house who could help him politically. Napoleon, to his credit, told them he preferred love to increase in power. This pearl set, consisting of tiara, brooch, ear drops, necklace and bracelets, was one of the emperor's gifts to his wife. At the fall of the empire, in 1870, it was part of the jewelry the unfortunate empress was able to bring away. She gave it to one of her loyal friends, who, at the risk of his own life, helped her to escape to England.

SOME LINK MOTIONS—HOW TO DRAW A STRAIGHT LINE

BY SAMUEL M. BARTON, UNIVERSITY OF THE SOHTH.

[Read before the Academy, November 27, 1914.]

The geometrician Euclid based his geometry on certain postulates. These postulates required that we should be able to draw straight lines and circles. By Euclid and his followers no demonstration was allowed that required any other construction than such as could be effected by straight lines and circles. In other words, the Greek geometer could use a straight edge for drawing a straight line and a "string" for describing a circle. With such limitations, as is well known, some of the problems proposed by the Greeks were insoluble. These postulates assume that a straight line can be drawn, and that a circle can be drawn. Now, can they? Describing a circle is the simpler of the two problems, assuming that we can keep the point of a pencil (say) at a constant distance from a fixed point called the center. This may be practically effected by employing a string or wire that is not easily stretched, or a bar, or link, fixed to a plane table by a pin about which it can freely turn, with a small hole at some other point to take the point of a pencil. This might be termed the simplest form of link motion, where one link is employed.

The other problem—to draw a straight line—is not so easy. It is doubtless commonly thought that it is a very simple operation to draw a straight line. All we have to do is to take a ruler or straight edge and lay it flat on the paper, and pass a pencil along its edge, and, behold, we have a straight line. But how do we know that the edge of our ruler is straight? Or, if it is straight, how was it made straight? This is exactly similar to the method of drawing a circle by running the point of a pencil around the edge of a silver dollar or some circular plate, by which operation we can not be sure that we get an exact circle unless we know that the edge of the coin or plate is a true circle.

The object of this paper is to call attention to some link-motions by means of which an accurate straight line can be drawn. These methods are not new, but one so seldom sees any reference to them that most probably they are not familiar to most of the members of the Academy, and, indeed, perhaps it is rather an accident if a mathematician hears of them.

The author's attention was called to their beauty a few years ago by seeing in the Congressional Library a copy of a small book by Mr. A. B. Kempe, of England, entitled "How to Draw a Straight Line." These linkages are of practical importance, as the principles involved are used in mechanisms of various kinds. They were discovered some fifty years ago. I have never seen it stated, but I presume up to that time the most reliable method of drawing a straight line was by getting the direction of a string held taut between two points. The uncertainty of this method is obvious, for it would be almost impossible to pass a pencil along the string without disturbing its alignment. This reminds us of the way carpenters get a line by using a chalked chord, which operation would hardly lay claim to scientific accuracy. The method that I am going to describe converts circular into rectilinear motion. We should notice that there are two kinds of rectilinear motion to be considered:

First—Continuous in a straight line of indefinite length.

Second—Reciprocating in a straight line of finite length.

The first of these is obtained by the methods of circular inversion first discovered by Peaucellier. The second, though truly rectilinear, would be more correctly described as motion in a flat, closed curve. For example, if a circle of radius a roll within another of radius $2a$, any point rigidly connected with the rolling circle and distant x from its centre will describe an ellipse, the axes of which are $2\ (x+a)$ and $2\ (x-a)$ in length. The nearer the point is taken to the circumference of the rolling circle, that is, the nearer x is to a, the flatter will be the ellipse, while its length approximates $4a$.

In this case the circular motion of the center of the rolling circle is converted into the elliptic motion of the attached point, and in the particular case in which the point is on the circumference of the rolling circle into the reciprocating rectilinear motion of the point.

James Watt first investigated the problem of getting straight line motion by the use of a three-link motion. Watt's so-called "Parallel Motion" was invented in 1784, and was employed in beam engines. This apparatus does not give "parallel motion," but approximate "rectilinear motion."

The simplest form of it is shown in Fig. 1. Here there are three links, AD, BC, and CD. A and B are fixed points, the radial links AD and BC are equal, and the point P is taken at the mid-point of the traversing link CD. The distance between the pivots, C and D, is such that when the radial links are parallel the line joining C and D is perpendicular to the radial bars. Then the curve described by

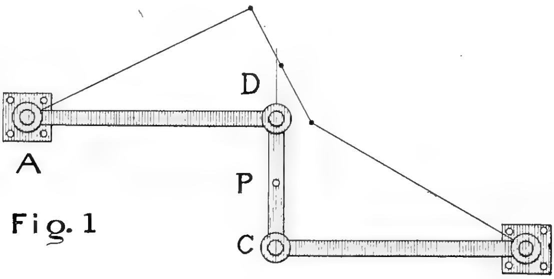

Fig. 1

the tracing point P is, if the apparatus does not differ much from its mean position, approximately a straight line. The reason of this is that the pivots C and D describe arcs of circles which are turned in opposite directions, and thus the point midway between them tends to curve neither the one way nor the other, and thus moves in a straight line. But this line is only approximately a straight line for a short distance, and it will be seen that if the linkage is moved much from its normal position, the Point P really describes a curve shaped like the figure 8.

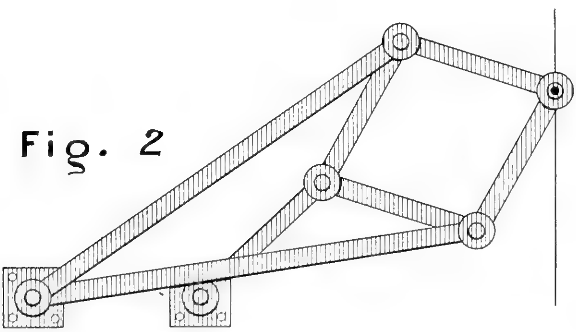
Fig. 2

In 1864, to omit mention of other attempts, eighty years after Watt's discovery, the problem was first solved by M. Peaucellier, an officer of Engineers in the French army. Peaucellier's apparatus is shown in Fig. 2. It has seven links.

There are first two long links of equal length. These are both pivoted at the same fixed point; their other ends being pivoted to the opposite angles of a rhombus composed of four equal shorter links. (This much of the apparatus is called a "Peucellier cell".) We then take an *extra* link, and pivot it to a fixed point whose distance from the first fixed point, that to which the cell is pivoted, is the same as the length of the extra link; the other end of the extra link is then pivoted to one of the free angles of the rhombus; the other free angle of the rhombus has a pencil at its pivot. That pencil will accurately describe a straight line. Now we must use a little mathematics to prove that the path of the pencil will be a straight line.

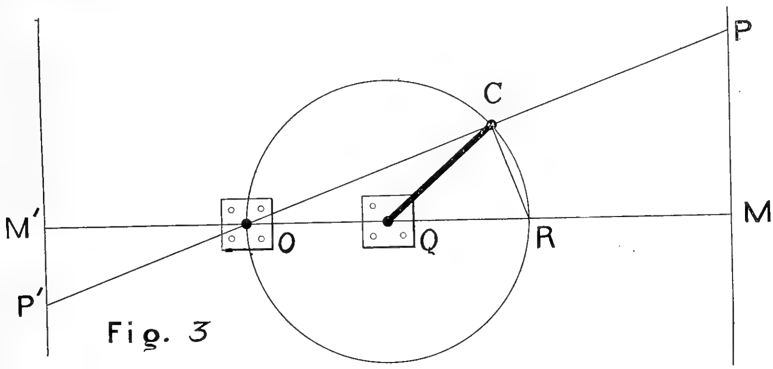

Fig. 3

In Fig. 3, QC is the extra link pivoted to the fixed point Q, the other pivot on it, C, describing the circle OCR. The straight lines PM and P′M′ are supposed to be perpendicular to MRQOM′. Now the angle OCR, being an angle in a semi-circle, is a right angle. Therefore, the triangles OCR, OMP are similar. Therefore

$$OC : OR :: OM : OP,$$

Hence

$$OC.OP=OM.OR,$$

wherever C may be on the circle. That is, since OM and OR are both constant, if while C moves in a circle, P moves so that O, C, P are always in the same straight line, and so that OC.OP is always constant; then P will describe the straight line PM perpendicular to the line OQ.

It is also clear that if we take the point P′ on the other side of O, and if OC.OP′ is constant, P′ will describe the straight line P′M′.

Now turning our attention to Fig. 4, which is a skeleton drawing of the Peucellier cell, we see that from the symmetry of the con-

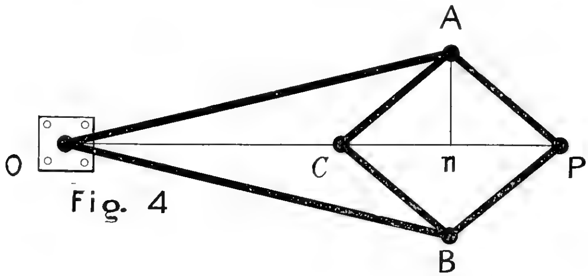

Fig. 4

struction of the cell, O, C, P all lie in the same straight line, and if the straight line An be drawn perpendicular to CP, Cn is equal to nP.

Now

$$OA^2 = On^2 + An^2$$
$$AP^2 = Pn^2 + An^2$$

therefore

$$OA^2 - AP^2 = On^2 - Pn^2$$
$$= (On - Pn) \, . \, (On + Pn)$$
$$= OC.OP.$$

Thus, since OA and AP are both constant, OC.OP is always constant, however far or near C and P may be to O. If then the pivot O be fixed to the point O in Fig. 3, and the pivot C be made to describe the circle in the figure by being pivoted to the end of the extra link, the pivot P will satisfy all the conditions necessary to make it move in a straight line, and a pencil at P will draw a straight line. The distance of the line from the fixed pivots will of course depend on the magnitude of the quantity $OA^2 - AP^2$, which may be varied at pleasure.

Now let us consider some modifications of the cell. The extra link, the one that produces the circular motion, remains the same as before, and it is only the cell that will undergo alteration.

If I take the two linkages in Fig 5, which are known as the "kite" and the "spear-head," and place one on the other so that the long links of one coincide with those of the other, and then amalgamate the coincident long links together, we shall get the original cells of Figures 2 and 4. If then we keep the angle between the long links, or that between the short links, the same in the "kite" and "spear-head", we see that the height of the "kite" multiplied by that of the "spear-head" is constant. Let us now instead of amalgamating the long links of the two linkages, amalgamate the short ones.

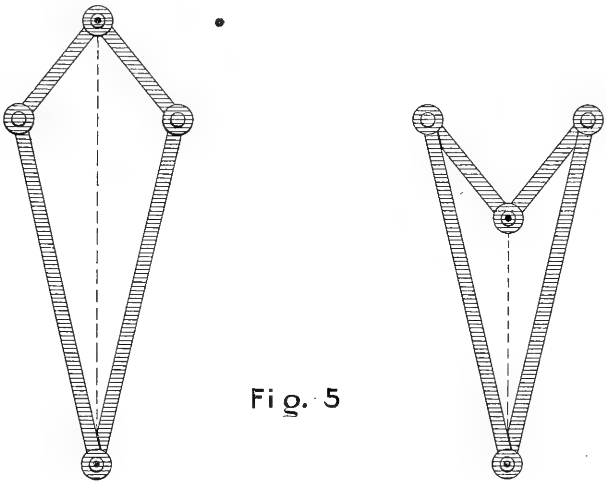

Fig. 5

We then get the linkage of Fig. 6; and if the pivot where the short links meet is fixed, and one of the other free pivots be made to move in the circle of Fig. 3 by the extra link, the other will describe, not

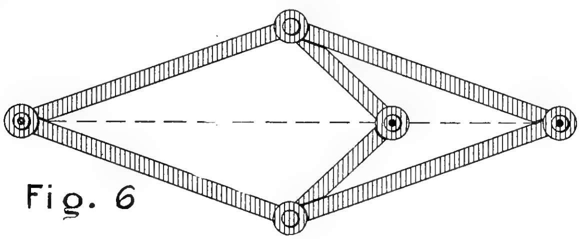

Fig. 6

the straight line PM, but the straight line P′M′. Mr. Kempe says that in this form the motion was applied most successfully to the air engines used to ventilate the Houses of Parliament.

Again, if to the ordinary Peaucellier cell I add two new links of the same lengths as the long ones, I get the "quadruple" cell of Fig. 7, called quadruple because it may be used in four different ways. Here the four points, O, C, P, O′, lie in a straight line such that C, P, are the poles of a positive cell, whose fulcrum is O or O′; and O, O′ are the poles of a negative cell whose fulcrum is C or P. In the first case we attach the free end of the *extra* link to C or P, O or O′ being fixed, and P or C describing the curve; and in the second case (negative cell), we attach the free end of the extra link to O or O′, C or P being fixed, and O′ or O describing the curve.

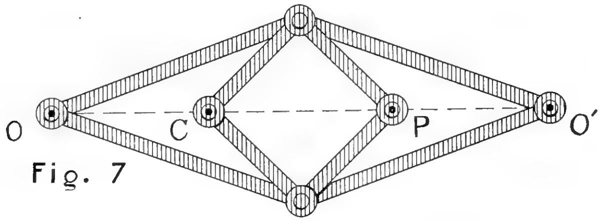

Fig. 7

By having two fulcra instead of one, the cell is made more complete, as sometimes we are thus enabled to describe more easily certain discontinuous curves. As an example of this use of the quadruple cell, Mr. Hart, in the *Messenger of Mathematics* for 1875, gives the construction of the Ovals of Cassini, a special case of which is the famous Lemniscate of Bernoulli.

The consideration of this quadruple cell leads us to an invention of Mr. Hart which gives us a five-link straight line motion instead of the seven-link motion of Peaucellier. I will close my paper by giving a brief description of this apparatus.

If we take an ordinary parallelogrammatic linkwork, in which the adjacent sides are unequal, and cross the links so as to form what is called a contra-parallelogram, Fig. 8, and then take four points on the four links dividing the distances between the pivots in the same proportion, those four points have the same properties as the four points of the double cell (what we called the quadruple

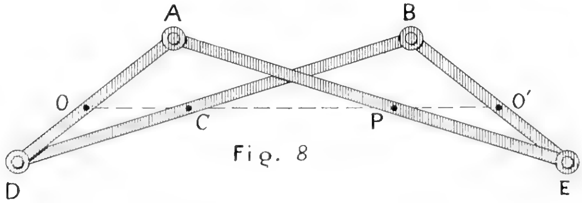

Fig. 8

cell). That the four points always lie in a straight line is seen thus: considering the triangle ADE, since

AO : OD :: AP : PE

therefore OP is parallel to DE, and the perpendicular distance between the parallels is to the height of the triangle ADE as OD is to AD; the same reasoning applies to the straight line CO′, and since AD : OD : : BE : O′E, and the heights of the triangles ADE, BDE, are the same, therefore the distances of OP and O′C from DE are the same, and OCPO′ lie in the same straight line. That the product OC.OP is constant is evident at once when we see that ODC is half a "spear-head" and OAP half a "kite"; in like manner it may be shown that O′P.O′C is constant, as also OC.CO′ and OP.PO′. Employing then the Hart cell, with the *extra* link as we employed Peaucellier's, we get a five-link straight line motion.

From the diagrams, it will readily be inferred that models of these linkages may be constructed without much difficulty. Pins for fixed pivots, strips of cardboard for links, string for the other pivots, and a drawing board or other smooth surface for a fixed base, are all we require. More durable links may be made of tin plate, or thin strips of wood, with some suitable form of pivot. And thus we can get our results visibly before us.

There are other special forms for converting circular into rectilinear motion—forms which involve "kites" and "spear-heads" arranged in a variety of ways. As special cases of one of these forms, first shown by Mr. Kempe, we have the ordinary pantograph used for enlarging or reducing any sort of plane figure, and the plagiograph (or skew pantograph) discovered by the celebrated mathematician Sylvester, which not only enlarges the drawing but turns it through an angle.

Similar apparatus are used for drawing various curves, but a description of these is beyond the scope of this paper. For instance, if in any of the forms of apparatus that I have described, instead of making the extra link (the link which compels a pivot to move in a circle) equal in length to the distance of its fixed end from the fixed end of the cell, we make it longer or shorter, the point P will describe, not a straight line, but a circle. This gives us an accurate and elegant method of describing a circle of very large radius without using its center. Again, there are linkages that enable not only a single point but a whole piece to move in a straight line. There are numerous instances in machinery where it is important that this be done; for example, the slide rests in lathes, punches, drills, draw-bridges, etc. The mathematician has discovered such link-motions, and the mechanic has not been slow to make use of these principles, often in a very elegant manner.

For information on the subject of linkages, I would refer to Kempe's "How to Draw a Straight Line", published by the MacMillan Co. in London, 1877, but out of print; to articles by Hart and

Kempe in the *Cambridge Messenger of Mathematics,* 1875 and 1876; and for a more general mathematical treatment of the subject to "Sur les Systemes de Tiges Articulees", par M. V. Liguine, in the *Nouvelles Annales,* December, 1875. There are other sources of information.

Some months after this paper was prepared, the author's attention was called to an American publication on this subject entitled, "Linkages: The Different Forms and Uses of Articulated Links", by J. D. C. DeRoos. This book (one of Van Nostrand's Science Series) was translated from *Revue Universelle des Mines,* and published in 1879. It can be obtained from the Van Nostrand Co.

NATURAL MEADOWS OF THE CUMBERLAND PLATEAU

BY L. R. NEEL, EDITOR SOUTHERN AGRICULTURIST.

[Read before the Academy, November 27, 1914.]

Some interesting phenomena of the Cumberland Plateau of Tennessee are the so-called "Natural Meadows". This term is applied by the inhabitants to tracts of land of varying areas that were free from tree growths when the white man came to Tennessee over a hundred years ago. A medium coarse wild grass grows on them and this has been a meadow for the section since its settlement.

These "natural meadows" are dotted around irregularly over the Cumberland Plateau. They vary in size from less than an acre to several acres. I know of one near Crossville, Tennessee, that must contain in the neighborhood of fifty acres. However, the latter is much larger than an average "meadow."

They are level as the prairie and practically free from tree growth. Along the branches that always flow out of them may grow some small water maples, some alders and possibly an occasional small tree or bush. These trees and brush interfered with the meadow practically none. The land was cleared when the country was settled and it stays cleared.

A sod of the sedgegrass, previously referred to, covers the ground, and with the exception of moss that grows freely down among the sedge plants, this is about all that grows in the "meadow" out away from the branch. The trees of the forest stop at the dead line for them, as though held back by magic. A few shrubs extend just a little beyond the trees and there the sedge begins.

The soil of the "natural meadow" is dark, being full of vegetable matter. Trees and parts of trees may occasionally be found buried in it. The depth varies from a foot or less to several feet. Probably three or four feet is a more common depth, while I have seen it exposed to a depth of six feet, where the branch had cut down. The soil is rather springy, and while a horse may be ridden over it in safety it would probably be unsafe to ride very fast in many places, especially in wet weather.

Evidently, trees and shrubs, as well as most herbaceous plants, do not grow in the "natural meadows," because soil conditions do not suit them. The forest around has stood there for centuries, probably, and scattered its seed over these open spaces and they have germinated but to find an unfavorable home and perish. The same has been true of the weed seed that have come from the woods and that have been carried there by birds and animals. Only the sedge-grass, the moss, and a few hardy trees and shrubs along the branches can survive the unfavorable conditions.

The soil is rather wet and very acid or sour. Surplus water gets out of it very slowly and this, with the great abundance of vegetable matter, causes the formation of a great deal of acid that is very harmful to most plants.

Many kinds of cultivated plants have been attempted on it but with very little success except where the soil was treated. Strange as it may seem, the soy bean has been found to thrive best. However, by using two tons of ground limestone or a ton of burnt lime per acre, Mr. J. E. Converse of the Tennessee Experiment Station, was able to grow fine crops of soy beans, millet, corn, and most other crops that he tried. By the use of lime he grew eleven tons of corn silage per acre, or about the equivalent of fifty-five bushels of corn. Drainage and lime are the main things needed to make a good farm soil out of the "natural meadows", although the soil is weak in phosphate and some potash would likely pay on potatoes and hay crops.

As to the probable origin of the "natural meadows" I do not claim to have built up any very strong scientific theory. Of one thing, however, all can be certain. Water played an important part. The vegetable matter has accumulated to a depth of three or four feet or more in the "meadows", while over the rest of the Plateau it is only from one to a few inches in depth. Water has kept the forest fires and the air from destroying the leaves and branches and trunks of fallen trees. These have been allowed to slowly undergo decay and, with the sand washed in, to make soil.

Evidence indicates that the "natural meadows" were once lakes or ponds. They are in basins out of which branches flow. The land slopes to them in every place except where the branch has its outlet.

We can imagine, then, small lakes into which leaves and twigs from the surrounding forest fell and washed, and, along with these, sand. The process gradually tended to fill the lake, while the flow of the stream out of it slowly drained it. This process kept up until finally the lake was converted into a swamp and then into the "natural meadows" of the present day. If this theory is correct a few more generations or centuries might be expected to complete the drainage to such an extent that the forest would gradually creep in upon the "meadows."

Whatever may be the exact origin of the "natural meadows," they are a very interesting natural curiosity of the many of our State.

PRESERVATION OF OUR FORESTS

BY R. S. MADDOX, FORESTER OF THE STATE GEOLOGICAL SURVEY.

[Read before the Academy, November 26, 1915.]

Last summer I stood on the banks of the Cumberland River and saw the water so low that navigation was practically suspended. The other day I again stood on the banks of this same stream and watched its seething waters boiling almost at their record height, carrying with them mud, trash, and portions of the farmer's crops. This river had risen almost forty feet in a week. On the one hand, we had last summer, drought; this fall, on the other hand, we had flood. What does this mean? What is the cause? These floods come from lack of forests. Our forests conserve the water supply by holding the rainfall in the earth. This is done by the aid of the litter of leaves and of trash which the trees throw off and which is collected on the ground, thus forming a loose surface that permits the water to readily soak into the earth and at the same time retains this moisture, letting it seep away gradually.

Without the forests, the rain flows rapidly off these unprotected slopes and mountain sides, taking away the water at once in a flood and leaving the underground water supply reduced for the maintenance of the streams in summer, and thus we have our drought.

Last fall I ascended the west slope of the mountain near Monteagle. This water-shed from the bottom to the summit had just been burned by forest fire. The underbrush and small bushes and some trees were killed or severely scorched. Not long afterward I had the opportunity to see the mountains around South Pittsburg in even a worse condition. Here the ground had been kept burned over for years. The trees that *had* withstood the fires showed the injurious effects of burns.

What does this all signify? Loss of timber to our State. Not only is the damage apparent in the actual trees burned, but these fires stand in a sense for future loss, since they have killed young growth that would have matured in years and brought in a revenue to the State. Furthermore, the fires have injured the ground by keeping the vegetable matter burned out and prevented new trees from springing up. Lack of forests, then, means lack of lumber and losses amounting to thousands of dollars.

Here in our Middle Tennessee there are lands cleared of trees for cultivation, so steep, that when their tree cover has been removed they have formed merely hills from which water has poured off in a flood, injuring agricultural lands below. If forests had been left on these steep hills the land *below* would have been protected. Furthermore, forests affect climate, furnishing cooling shade in summer and tempering the cold winds of winter.

Now we can sum up some of the results of forest destruction: First, floods; second, drought; third, loss of timber; fourth, injury to our agricultural lands, and, fifth, injury to our climate. It will be noted that I have not mentioned our need of the beauty of trees. But this is a phase of the question that I believe needs no emphasis here, for what would be our lives without our shade trees, our forested mountain slopes and our wood-rimmed lakes? We scarcely can estimate the importance and value of the tree's influence on our higher natures in teaching us beauty of tree form, beauty of color, beauty of God's universe. Let us turn now to the other side of the picture. Forest destruction is with us today. Forest conservation and reforestation is to be one of our State's tasks for the future.

First, I am going to speak of forest conservation. What does it mean? It means, in short, keeping those lands that should be retained as forests in a state of permanent preservation and production. This is accomplished in part by fire protection. Let me outline the system employed on the Plumas National Forest which may vary in certain details from other localities, but which in general, outlines the principles necessary for a good working system. There are stationed men called lookouts on certain of the most prominent mountain tops of the forest, whose duty it is to watch for fires and to telephone to the central forest service office on the forest. These men have their field glasses and maps. They have their maps oriented north and south and marked off in degrees from their lookout station as a center. They sight along their maps in the direction of the fire, read the angles, and telephone their bearings into the forest service office. This being done by two or three stations enables the head office to locate the fire very definitely by use of the office map, and then the office telephones the *ranger,* in whose district the fire is located. The ranger collects his men as fast as possible and goes to the fire. By this method of fire protection, it is estimated that millions of dollars have been saved on our national forests in timber preservation over and above the cost of running this system. In Connecticut and New Hampshire, a State system very similar to this forest service method is employed with success.

Conservation of our forests does not necessarily mean that we should keep all our forested lands in timber. Lands that are better for agriculture and which can be maintained for agricultural land should be turned over to agriculture. Much land on national forests today has been classified by men in the service as agricultural land and therefore opened to entry, and the land that is considered naturally more valuable for forests than agriculture is reserved for forested areas.

In the management of the forested lands an effort is made if possible to secure a revenue from the timber. This is accomplished by selling timber off certain areas to private companies. The forest officers retain the right to mark the timber that shall be cut. The principle of cutting, in brief, is this: to remove the mature and decadent timber, which has reached its greatest value, so as to give the young and thrifty trees a chance to mature, and for the open places made by the removal of trees to be restocked by seedlings. In the removal of the timber there is one object kept steadily in view, viz., to preserve and perpetuate the species which is considered best suited to that area. In cutting trees, forest service men insist that the lumbermen cut the stumps low. At first glance, this would appear a small consideration. As a matter of fact, it has been carefully figured that the money saved to the lumberman by cutting low stumps pays him for the expense of felling the timber.

In this way, the United States attempts to secure a revenue from her forests and at the same time she preserves her young and thrifty trees for a constant forest cover.

On some of these forests grazing is permitted under certain conditions, but wherever stock proves to be a detriment, either to young trees or to the soil through tramping it, it is forbidden.

Both in national forests and in State work, experimentation is carried on extensively; the growing of nursery stock and experiments in tree growth on different soils under different conditions are tried out. An effort to establish new, good species of trees in a State is made.

It is not to be understood that all the lands on national and State forests are timbered. Frequently thousands of acres with no tree growth occur in one forest. It is the business and effort of the officials in charge to undertake and work out some plan by which the treeless areas may once more become stocked with trees. This is accomplished in some cases by planting tree seeds; in others it may be necessary to plant seedlings raised in a nursery. The State of Pennsylvania, for instance, is handling some of her State forest land in this way, setting out thousands of seedlings every year.

Now, what we want for Tennessee is a well organized system of forest conservation. We are yet young in forestry. We have still to learn many facts and conditions relative to the needs of the State in order to work out a plan. It must be through a knowledge of the principles of tree growths, their value and influence, that the forested land and the land to be kept under forest cover shall be cared for and managed. The State has no State forests yet. All the wooded lands are under private ownership and their care is primarily in the hands of the people. Every man, woman, and child in the State should know something of the fundamental facts about trees, forests, and their influence. The boys and girls of today are the men and women of tomorrow. The lifetime of one generation is inconceivably short compared to the lifetime of a State. The people of today are preparing conditions for the people of tomorrow, which they must accept whether they will or not. The parent has no legal or moral right to place a handicap upon his child; and, in a broader sense, the generation of today must not handicap his child, the generation of tomorrow. I believe the education of our children to appreciate the value of our natural resources should form as great a part of their training as mathematics, history, art, philosophy, or religion. I shall be glad when every individual in the State shall have a working knowledge of the influence of trees and forests and man's dependence upon them, and a will to conserve such a great and beneficent resource.

JAMES ADAIR LYON, A.M., PH.D., LL.B.

BY J. I. D. HINDS, CASTLE HEIGHTS SCHOOL, LEBANON, TENN.

[Read before the Academy, November 26, 1915.]

In the death of Dr. James Adair Lyon, Professor of Physics and Astronomy in the Southwestern Presbyterian University, at Clarksville, Tennessee, the Tennessee Academy of Science has lost a valuable and enthusiastic member. After several months of illness, he died at his home in Clarksville on September 12, 1915, and was buried two days later. The authorities of the University, in which he had been a professor for more than thirty years, and the officers and members of the Presbyterian Church, of which he was a ruling elder, gave him special honors at his funeral.

Dr. Lyon's father, Rev. James Adair Lyon, D.D., was a distinguished Presbyterian minister. He was one of the organizers of the Southern Presbyterian Church, a member of its first General Assembly in 1861, and moderator of the third Assembly which met in 1863. He was Professor of Mental and Moral Philosophy in the University of Mississippi, and died in 1882.

Dr. Lyon was born in St. Louis, Mo., July 19, 1852. When quite young, he moved with his father to Columbus, Miss., where he grew to young manhood and was prepared in private schools for college. He entered the Sophomore Class in Princeton University in 1869, and in 1872 graduated second in a class of eighty. He was awarded the J. Cooke fellowship of $600.00 for excellence in mathematics. He received from his Alma Mater the degree of Master of Arts in 1875 and the degree of Doctor of Philosophy in 1880. He studied law in the University of Mississippi and graduated in 1874 with the degree of Bachelor of Laws. He was married in 1875 to Miss Elizabeth Barringer, of Oxford, Miss., who survives him. He leaves three sons and one daughter, Professor J. Adair Lyon, of Tulane University, New Orleans; Mr. Theodoric Lyon, of New Orleans; Professor Scott C. Lyon, of the Presbyterian University, of Clarksville; and Mrs. W. E. Cox, of Columbus, Miss. He is also survived by his brother, Dr. A. A. Lyon, of Nashville, and his sisters, Mrs. John W.

Childress, of Nashville, Mrs. E. M. Smith, of Holly Springs, Miss., and Mrs. Bromfield L. Ridley, of Murfreesboro, Tenn.

Dr. Lyon was an elder in the First Presbyterian Church at Clarksville and a useful and devoted member of the congregation. I quote from a tribute published at the time of his death in the Clarksville Leaf Chronicle:

"Simple in his faith, sincere in his piety, unfaltering in his devotion to duty, unaffected in his manners, his was a most unusual service. As Superintendent of the Sunday School, as Superintendent of the South Clarksville Mission, as Superintendent of the Negro Mission, always and everywhere, he was regular, conscientious, faithful and efficient. Generous in his giving, upright in his dealings, duty was his watchword, and love was his motive. No night was too dark, no cold or heat or rain too severe, to deter him from being at his post. Wise as a councilor, loyal to his friends, just and fair to all alike, he earnestly and humbly endeavored to live the gospel which he professed."

Dr. Lyon devoted his life to teaching. He was first an instructor in York Collegiate Institute, York, Pa., in 1874. In 1876 he became Professor of Mathematics and Natural Science in Highland University, Kansas. In 1878, he became Professor of Chemistry and Physics in Washington and Jefferson College, Pennsylvania. In 1885 he was elected Stewart Professor of Natural Science in Southwestern Presbyterian University, and in 1900 was transferred to the chair of Physics and Astronomy in that institution, which position he held at the time of his death.

Dr. Lyon was associated with me for many years at Monteagle Assembly as a teacher and a lecturer. He was a painstaking student of the sciences, was an authority in his department, and was a successful teacher. As members of the Tennessee Academy of Science, we are glad to pay this loving tribute to his memory, and to express our regrets that we are no longer to have the results of his researches, the enjoyment of his friendship, and the help of his counsel and advice.

CHEMISTS' PRESENT OPPORTUNITIES AND DUTIES

BY J. I. D. HINDS, CASTLE HEIGHTS SCHOOL, LEBANON, TENN.

[Read before the Academy, December 1, 1916.]

For my present purpose I shall divide chemists into two classes, pure or theoretical chemists, and industrial chemists. To the first class belong those who are doing research work independently, that is, in nobody's interest, with the sole purpose of adding to the store of chemical knowledge, and without the idea of making money out of the results of their researches. Chemists of this class have not been particularly affected by the European war, except as their work has been interrupted, especially in the countries at war. They are usually in the employ of universities, or of the national or State governments, and are working for the advancement of science and for the general good.

To the pure chemists there are now open many rare opportunities. There are vast fields unexplored in physical chemistry, electrochemistry, radiochemistry, in the study of the nature of the atom and of the molecule and of colloids. None of these bid fair to have much commercial importance unless it should be in the study of the atom. If we can ever learn how to decompose and recompose the atom, we may find access to stores of energy which will dwarf all those which we now possess. Our utilizable sources of energy are chemical action, water power, electricity, and the sun. Water power traces back to the sun and electricity is made available through chemical or mechanical energy. The atomic disintegration of a gram of radium or of uranium develops something like a million times as much energy as the combustion of a gram of coal. This energy of atomic decomposition is peculiar, having characteristics not possessed by the energy of chemical action. This atomic decomposition is spontaneous and we know of no way either to cause it or prevent it.

The pure chemist is altruistic. He thinks little of the commercial value of his discoveries. He takes as much interest in estimating the weight of the hydrogen atom as in measuring the heat of combustion of a pound of coal. It is to him, however, that real progress is mainly due. He discovers fundamental facts and laws and establishes working hypotheses and theories. The industrial chemist simply applies what the pure chemist discovers. To the pure chemist much honor is due. He is doing his duty well. His chief reward will lie in the consciousness of having enlarged the field of knowledge, and his name will be honored by future generations after the industrial chemist has been forgotten.

Because of the European war and the large decrease of imports, the opportunities of industrial chemists have been wonderfully multiplied. So great is the demand for chemists that the young men are being taken from the universities before they finish their graduate courses and put to work with inadequate training. There has been an increase in almost every line of chemical manufacture, and nearly all manufacturing is now more or less chemical. The increase in prices has caused an increase of output and an extension of business. Many factories have doubled and quadrupled their capacity. The largest development has been in the manufacture of those substances which were formerly imported from Germany and Austria, such as anilin dyes, synthetic vegetable dyes, coal and coal tar products, potassium and barium salts, nitrates and so forth. Of the 29,000 tons of dye stuffs used annually in the United States, 6,000 tons were home made before the war; now it is estimated that three-fourths of the dyes used are made in this country. In the same way the separation and refinement of the coal tar products has been so developed in the past two years that the demand can now be almost supplied by the home manufacture. The production of nitrogen compounds has been greatly increased by saving ammonia as a by-product of the coke and gas industries. In addition to this we have as possibilities synthetic ammonia and the oxidation of atmospheric nitrogen. When the twenty million dollar government plant is finished at Mussel Shoals, our supply of nitrogen compounds will be adequate not only for fertilizing purposes, but to supply the high explosives in case of war. There is so far no sufficient visible supply of potassium compounds. This is being partially compensated for by the use of sodium compounds which in many cases serve as well. The government has taken the matter in hand and is looking for sources of potassium, so far with but little success.

That the chemists and manufacturers are improving the present opportunities is evidenced by the recent chemical exposition in New York. There were more than two hundred exhibitors and some three hundred and thirty exhibits. These covered so nearly every field of chemical endeavor that one is convinced that, should we be indefinitely blockaded by an enemy, we should suffer but little inconvenience.

The industrial chemist should be honest. Chemists as a class are among the most honest of men. Their testimony is usually given full credit. A false report from a chemist disgraces him with the profession. Falsehood is contrary to the spirit and genius of the subject. Accuracy and fidelity to fact is the first principle of the chemist. It is true that some manufacturers instruct their chemists to adulterate the goods and hide the adulterations, but this is the exception rather than the rule. Any first-class chemist under such requirements will seek another employer.

A word now about chemical secrets. There are really no chemical secrets. Whenever a new compound is discovered its description and the method of its preparation are published in the journals. It is one thing, however, to make a small quantity of a substance in the laboratory, and quite another to make it by the ton in the factory. Nearly all chemical secrets are secrets of the factory, secrets of manipulation. These are legitimate secrets and the chemist should keep them faithfully for his employer. The best factory methods are learned only by prolonged and costly experimentation. It is said that one German dye factory spent three million dollars before it sold any of its output.

It is thus seen why the dye business has progressed slowly in this country. The large corporation has many advantages. In the first place, it can afford to incur the expense of the necessary experimentation. In the second place, it employs the best chemical experts and carries out elaborate researches. The General Chemical Company, the General Electric Company, the Edison Company, and other such corporations are spending much money in researches and are making marked discoveries from time to time.

All things considered, I think that the chemists are rising to the occasion and acquitting themselves well. Indeed, in many respects they are leading the world. The American Chemical Society has 8,200 members. It publishes three of the best chemical journals in the world. The Chemical Abstracts is the most complete abstract journal published. It abstracts the contents of some four hundred journals using about two hundred and forty abstracters. The Industrial Journal is in the very front rank and the Journal of the American Chemical Society as the record of original research in America is the peer of any other chemical journal published. Thus, in both pure and applied chemistry, America stands abreast of any other nation in the world.

One of the serious problems which will have to be faced in the future is how to get an adequate supply of motor fuel. At the rate of present consumption of gasoline it will not be a great many years until the supply will be far below the demand. The most probable substitute is alcohol. It is estimated that if the saw mill waste of the country were utilized, it would produce many millions of gallons of alcohol. To this might be added a large amount of organic waste which might be converted into alcohol. One thing seems quite certain, that we must ultimately look to plant life for our fuel as well as for our food. If alcohol could be made and sold for about 10 cents a gallon the question of motor fuel would be solved.

JAMES M. SAFFORD

BY JOHN T. MCGILL, VANDERBILT UNIVERSITY.

[Read before the Academy, December 1, 1916.]

James Merrill Safford was born at Janesville, Ohio, August 13, 1822. He came of an English family that landed in Massachusetts in 1630. Having prepared for college in the Janesville schools, he attended the Ohio University at Athens, from which he received the degree of A.B. in 1844, and the degree of A.M. in 1846. He then went to Yale College and pursued a special scientific course, and for this and his investigations later he received the Ph.D. degree from Yale in 1866.

While at Yale, in 1848, an application came for a teacher of science at Lebanon, Tennessee. Professor Silliman recommended him for the place, and advised him to accept, telling him that Tennessee was a fine field for geological exploration. So he came to Lebanon in 1848 as Professor of Chemistry, Natural History and Geology in Cumberland University, a position he held for twenty-four years. Becoming Professor of Chemistry in the Medical Department of the University of Nashville in 1872, and of the Medical Department of Vanderbilt University in 1874, he filled the chair of Chemistry for both departments during their union, from 1874 to 1894. In 1885 he succeeded Professor Lupton as Dean of the Department of Pharmacy in Vanderbilt University, and for the year 1885-86 he had charge also of the School of Chemistry in the Academic Department. His work of fifty-two years as a teacher, one-half of which was in connection with Vanderbilt University, closed in 1900; but the University continued to print his name in the Faculty as Professor Emeritus. His letter of resignation contains the following paragraph:

"I hereby tender my resignation as Professor of Natural History and Geology in Vanderbilt University. I am impelled to this course by failing strength and ill health. To me this severance is a breaking of many strong and tender ties. With me the University loses the last member of the original Academic faculty. A band of noble brothers was that faculty. I look back on them with much appreciation. One by one they have dropped out of the life of the University, and now with my withdrawal no one of the band is left."

From the above synopsis it may be seen that Dr. Safford was a teacher for more than fifty years in colleges and universities—a remarkable record. While geology was his chief subject, he also gave instruction at times in general biology, botany, zoology, mineralogy, and chemistry. His teaching was characterized by simplicity, clearness and thoroughness. It was also eminently practical, doubtful hypotheses and speculations being discarded. Unessential technicalities were avoided. His lectures were complete and logical, and his descriptions of specimens, models, and drawings were so clear, accurate, and complete that when he finished the description there was no excuse for any one to say he did not understand. Of course, a student of exceptionally quick perception, or one satisfied with superficiality or in haste to cover much ground might sometimes become impatient, but not the average student nor the plodder. The students all liked him, most of them became interested in the subjects he taught, and every one felt that he was acquiring useful knowledge in a delightfully easy way. The influence of the teacher in training the mind, in inspiring the love and acquisition of knowledge, in moulding character, is something that can not be measured nor valued. But it is one of the great forces in the world for good; and this kind of influence was exerted in no weak or uncertain way by Dr. Safford for fifty years.

One of the most interesting and instructive features of his teaching consisted in excursions to the country for the practical study of botany and geology and the collection of specimens. Sometimes extensive trips were made at the close of the session, equipment for camping out being provided by the University. The class of 1879 tramped from Nashville to the eastern boundary of the State. Sections were made of all the geological strata represented, and the coal mines of Tracy City and the copper mines of Ducktown were explored.

Dr. Safford's life work was dual. He was an educator and a geologist. He took the geology of Tennessee as his subject, and he began to investigate it as soon as he arrived in Lebanon in 1848. His first paper on "The Silurian Basin of Middle Tennessee, with notices of the strata surrounding it," was published in the American Journal of Science in 1851. The investigations for this paper were limited to a portion of Middle Tennessee, but on his appointment as State Geologist in 1854 he entered upon a general study of the whole State, and presented the results of his investigation in 1855 to the General Assembly in his first biennial report, entitled, "A Geological Reconnaissance of the State of Tennessee".

He was continued in the office of State Geologist until 1899 except during the time of the Civil War and the period of reconstruction, from 1860 to 1871. His most important State Report, probably his greatest work, was made in 1874, and was published by order of the General Assembly, being "Geology of the State of Tennessee, pp. 550, with plates and map". This same work, revised and enlarged, was included in "An Introduction to the Resources of Tennessee", published in 1876 by order of the Bureau of Agriculture. Two other important reports which he made as State Geologist were, one in 1887, consisting of more than 100 pages, to the Bureau of Agriculture on "The Agricultural Geology of Tennessee", and one in 1889 to the General Assembly, dealing principally with the coal area of the northwestern portion of the Tennessee coal fields.

Reference only can be made here to other papers of his published in *The American Journal of Science, 2nd series,* Vol. XVI, XXII, XXVI, XXXI, XXXVII, XLII; in the *Naural Gas Supplement,* No. 2; *American Manufacturers and Iron World,* December 30, 1887; the *Proceedings of the Academy of Natural Sciences* of Philadelphia, 1889; in the *American Geological Railway Guide,* 2d edition, 1890; in the *Bulletin of the Geological Society of America,* volumes III, XIII; and in the *American Geologist,* volumes XIII and XVIII. Their titles are given in the bibliography appended to this paper.

Dr. Safford was one of the judges at the International Exposition at Philadelphia, 1876, and made the report on the geological and mineralogical collections there. He served in like capacity at the Cotton Exposition at Atlanta in 1882, and at the Louisville Exposition in 1883. He was the chief of the department of Geology, Mineralogy and Mining at the Tennessee Centennial Exposition, 1897.

Beginning in Vol. I of the Tennessee State Board of Health, 1880, and continued in Vol. II, 1885, is an article by Dr. Safford on "The Geological and Topographical Features of Tennessee in relation to Health and Disease." He probably planned a more complete discussion of the question, as in the article only three of the eight natural divisions of the State are considered.

Dr. Safford shrank from public speaking, debates, and controversy. He preferred to write what he had to say on public occasions, but if there was no opportunity for this he presented his views in a plain, matter of fact way, and left them without further comment to the judgment of those to whom they were addressed. Several short addresses on public occasions were published in pamphlets, mention of which is made in the appended bibliography. His last published papers are reminiscent in character. One of these is "The Housing of the Hay; An Escapade of College Life", read at the Centennial Anniversary of the Ohio University, June 1904, and another was read at the meeting of the Texas Alumni Association of Vanderbilt University in 1906.

Troost preceded Safford in the study of geology of Tennessee. How much of it he had brought to light when the latter came to Tennessee the writer does not know, but doubtless what is known of it today is due chiefly to the investigations of Safford. He is an authority on this subject, and his name as a scientist will be perpetuated through his work in the development of the geology of Tennessee.

The services of Dr. Safford to Tennessee as State Geologist were of great material value. Largely through his investigations the great mineral wealth of the State became known at home and abroad. It was through his advice that the State, in 1899 (?), purchased the Brushy Mountain Coal Mines, which for a number of years gave employment to its convicts and were a regular and profitable source of revenue. His salary as State Geologist was far from commensurate with the value of his services. He was devoted to the work, and the salary was no consideration with him. Whether the legislature appropriated little or nothing, he made no demand or complaint. And it is specially worthy of mention that notwithstanding the meager compensation he received and the opportunity his knowledge of the value of undeveloped mineral properties gave him for acquiring wealth, he never used the information for his own financial benefit. As far as I know, he never owned an acre of coal land or of iron ore property. The State of Tennessee ought to erect a monument and statue to the memory of this man.

Dr. Safford was intimately associated with Silliman and was held in high esteem by LeConte and other distinguished American geologists. He was a member of the Geological Society of America from its organization and was one of the oldest members of the

American Association for the Advancement of Science. Aside from membership in scientific bodies, he was a Mason of high rank.

In his religious affiliations Dr. Safford was a Presbyterian. By precept and example, he carried his Christianity into his daily life. For example, on the geological excursion of 1879 mentioned above, the young men were gathered together for prayers every morning before breakfast, and his association with these young men, his interest in instructing them, provision for their comfort, solicitude for their good reputations, was like that of a father.

In 1859 Dr. Safford married Mrs. Catherine K. Owens, of Lebanon, Tennessee—a happy union lasting until her death at Dallas, Texas, in ——. Their only child was Mrs. D. M. Morrow, of Dallas, Texas, with whom he made his home after his retirement from active life in 1900. For seven years he lived there in quiet comfort and contentment, with the respect and honor of all who knew him. He passed peacefully away on June 2, 1907, and was buried at Dallas.

LIST OF GEOLOGICAL AND OTHER PUBLICATIONS OF JAMES M. SAFFORD, 1851-1904.*

1. The Silurian Basin of Middle Tennessee, with notices of the strata surrounding it. Amer. Jour. Science, XII, 2d series, 1851, pp. 352-362 and one Plate.

This deals with the topography and formations of the given region.

2. Note on Tooth of Petalodus Ohioensis. Amer. Jour. Science, 2d series XVI, page 142, 1853.

By a misprint *Petalodus* is made *Getalodus*.

3. A Geological Reconnaissance of the State of Tennessee; being the Author's First Biennial Report, presented to the 31st General Assembly of Tennessee, 1855, 8, pp. 164 and Map.

4. Remarks on the genus Tetradium, with notices of the species found in Middle Tennessee. Amer. Jour. Science 2d series, XXII, 1856, pp. 236-238.

Four species are proposed and their stratigraphical horizons indicated.

5. Second Biennial Report or Statement to the General Assembly of Tennessee. Phamphlet of 11 pages, 8, 1857.

A short statement wholly of an administrative character.

6. On Tennessee Geological History. Amer. Jour. Science, 2d series, XXVI, 1858, pp. 128-129.

This discusses the unconformability of the Upper and Lower Silurian strata in Tennessee, and the probable existence of an island, in Middle Tennessee, in the Upper Silurian and Devonian Seas.

7. The Upper Silurian Beds of Western Tennessee; and Dr. F. Roemer's Monograph. Amer. Jour. Science, 2d series, XXXI, pp. 205-209.

A section of the rocks is given, showing for the first time, the separation, in the region, of the Lower Helderberg and Niagara.

*This bibliography, with notes, was made out by Dr. Safford a short time before his death. As far as I know, it has never been published.

8. On the Cretaceous and Superior formations of West Tennessee. Amer. Jour. Science, 2d series, XXXVII, 1864, pp. 360-372, with Plate.

A general notice of the formations of West Tennessee.

9. Note on the geological position of Petroleum Reservoirs in Southern Kentucky and in Tennessee, with section of the formations. Amer. Jour. Science, 2d series, XLII, 1866, pp. 104-107.

10. Geology of the State of Tennessee, 8, pp. 550 with plates and map. Nashville, Tenn.

A State Report, published by order of the General Assembly of Tennessee.

11. An introduction to the Resources of Tennessee, 8, pp. 1204, with plates and a Geological map, 1874.

This work was prepared and published by order of the Tennessee Bureau of Agriculture, W. H. Jackson, President; J. B. Killebrew, Secretary and Chief Editor, and J. M. Safford, Geologist and Chemist.

The geology of the work and the map as well as the descriptions of a number of the counties are by J. M. Safford.

12. Enumeration of the Geological and Mineralogical collections at the International (Centennial) Exhibition, 1876, Philadelphia.

Reports and Awards, Group 1, 8vo., 1878, Philadelphia, pp. 353-386.

The names of the states and countries exhibiting are given with brief notices of their collections.

13. The Elementary Geology of Tennessee. James M. Safford and J. B. Killebrew, 1876. Nashville, Tenn.

A school book of 255 pages.

14. The Geological and Topographical Features of Tennessee in Relation to Disease. Volumes I and II of the Reports of the Tennessee State Board of Health, 8vo., 1880 and 1885. Nashville.

In Vol. I are discussed: The State in General, the Unaka Mountain region, and the Valley of East Tennessee, pp. 237-317;

In Vol. II, The Cumberland Table-land or Plateau, pp. 365-386.

Of the eight natural divisions of the State, three are considered.

15. As Special Census Agent, Census 1880. Report on the Cotton Production of the State of Tennessee, with a discussion of the State's topographical, geological and agricultural features, and a note on Cotton Production in the State of Kentucky, large 4vo., 119 pages, 1883. Washington, D. C.

16. The Natural Features and Resources of the South; remarks before the Southern Immigration Association. Proceedings of the Session held in Nashville, March 11-13, 1884. Nashville, Tenn., pp. 16-25.

17. Special report, or notes on the geology of parts of West Tennessee, with a table of the formations, to which are added notices of certain mineral veins in Middle Tennessee; and II, A Report on the Agricultural Geology of Tennessee.

These make up pages 55-163 of the biennial report of the Commissioner of Agriculture of the State, A. J. McWhirter, 8vo., 1887, Nashville, Tenn.

Most of report II, above, is a reprint of parts of the Author's Census Report of 1883.

18. The Topography and Geology of Middle Tennessee as to Natural Gas. Natural Gas Supplement, No. 2, Amer. Manufacurer and Iron World, December 30, 1887, pp. 21-22. Pittsburg, Pa.

The paper includes topographical divisions, a table of formations, historical notes and a discussion of the facts.

19. An edition of the Geological Map of Tennessee, 1888.

Prepared to accompany Report of Commissioner of Agriculture, B. M. Hord, Nashville, Tenn.

20. Descriptions of new species of Fossil Crustacea from the Lower Silurian of Tennessee, with remarks on others not well known. J. M. Safford and A. W. Vogdes. Pamphlet, 8vo., 4 pages. Printed in advance of the Proceedings Acad. Nat. Sciences of Philadelphia, 1889. Fort Hamilton, N. Y. H. 1889.

The species Ampyx Americanus is described in this, and the species Encrinurus varicostatus, Walcott, and Chasmops Troosti, Safford, further illustrated and commented on.

21. Report to the General Assembly of the State of Tennessee. Senate Journal, 8vo., 1889, pp. 715-739. Nashville, Tenn.

The report refers to certain iron ores, mineral waters and clays in West Tennessee, and iron ores and building materials in East Tennessee, but chiefly deals with an important coal area in the Northwestern portion of the Tennessee coal fields.

22. The Water Supply of Memphis. A report made to the State Board of Health of Tennessee. State Board of Health Bulletin, February 20, 1890, 8vo., pp. 98-106. Map and cuts. Nashville.

This report gives a complete section of the formations underlying Memphis, having, in round numbers, an aggregate thickness of 1,200 feet, 1,156 of which are below high water of the Mississippi.

23. Tennessee. List of formations and notes. American Geological Railway Guide (McFarlane), 2d edition, pp. 401-405. 1890.

24. The pelvis of Megalonyx, and other bones from "Big Bone Cave," Tennessee. Bull. Geological Society Am. III, 1891, pp. 121-123.

The pelvis of the animal up to the date of the discovery of these bones was not known.

25. The Resources of the Valley of the Cumberland River; remarks before the Cumberland River Improvement Association at their Convention held in the Commercial Club rooms, Nashville, November 18, 1891. Pamphlet, pp. 26-33.

26. The Middleton formation of Tennessee, Mississippi and Alabama, with a note on the formation at La Grange, Tenn. The American Geologist, IX, 1892, pp. 63-64.

27. Address on Behalf of the Faculty. Delivered at inauguration of Dr. James B. Kirkland as Chancellor of Vanderbilt University. "Addresses Delivered at the Inauguration." Pamphlet, Nashville, Tenn., 1893, pp. 11-14.

28. Phosphate-bearing Rocks in Middle Tennessee. Preliminary notice. The American Geologist, Vol. XIII, 1894.

29. Tennessee Phosphate Rocks. A paper read at the Farmer's Convention, Columbia, Tenn., November 17, 1894. Reprinted from the Report of the Commissioner of Agriculture, Hon. T. F. P. Allison, pamphlet, 8vo., pp. 16.

30. A New and Important Source of Phosphate Rock in Tennessee. American Geologist, Vol. XVIII, 1896, pp. 261-264.

31. The Elements of the Geology of Tennessee, prepared for the use of the Schools of Tennessee. James M. Safford and J. B. Killebrew, Nashville, Tenn., 1900, pp. 264. This is more than a new edition of the book of 1876; it is essentially a new work.

32. Classification of the Geological Formations of Tennessee: includes the more recently recognized formations; introduces some changes and corrects certain errors. Bulletin of the Geological Society of America, Vol. 13, 1901. pp. 10-14.

33. Horizons of Phosphate Rock in Tennessee; notices the four beds of phosphate and an occurrence in masses from precipitation. Bulletin of the Geological Society of America, Vol. 13, 1901, pp. 14, 15.

34. The Housing of the Hay; An Escapade of College Life. The Mirror, Ohio University, Athens, Ohio; Vol. 3, Ser. No. 9, 1904, pp. 139, 140.

The above and a paper giving recollections of the author's professors, class and college mates of 1844, were read at the Centennial Anniversary of the Ohio University, June, 1904.

THE INTERRELATION OF PLANT AND ANIMAL PATHOLOGY

BY SAMUEL M. BAIN, UNIVERSITY OF TENNESSEE.

[Read before the Academy, December 1, 1916, being the Annual Address of the retiring President.]

The high degree of specialization attained by scientific investigators within the past century has been one of the factors contributory to the remarkable progress of science during this period. At the same time it must be admitted that men with a very much narrowed field for inspection are in distinct danger of underrating the importance of fields foreign to them. They are also in danger of too hasty generalizations from their observed facts, and oftentimes may fail to generalize where generalization is distinctly indicated.

I have dared to attempt to discuss before you this evening certain analogies and antitheses in two fields of science which have rarely, if ever, been cultivated by the same individual. I have feebly attempted to cultivate a small area of one of these fields, but make no claim to knowledge at first hand in the other. I have been able to gather a few facts in recent years concerning plant pathology, but know very little in a scientific way of animal or human pathology, however intimate an acquaintance I may have acquired as host in the entertainment of a liberal share of pathogenic parasites in my own body.

Yet the history of the advancement of medical science in the last fifty years is hardly such as to discourage trespass on its territory by cultivators of other fields. It would be difficult, for instance, for medical science to pair two peers of Pasteur and Metchnikoff, the one a poacher from the field of physics, the other a zoologist. What a man sees as an investigator in any field of observational science is not dependent so much on the image cast on his retina, as upon the images impressed on his mind by former study and his ability to call up and to correlate these mental images with those new ones presented. The scientific mind is then a sort of kaleidoscope whose geometric pictures depend upon the crystalized materials that lie within it as well as upon the reflecting walls of the instrument itself. For this reason a man with an entirely new set of ideas imported from a different but related field may discover relations not before dreamed of by occupants of the invaded territory. Plant physiology, for instance, has recently received such a shock from the ingenious researches of Bose, the Hindoo physico-physiologist.

I hasten, however, to assure you that I have made no discoveries, sensational or otherwise, to announce to you this evening. It is my ambition merely to bring to your attention certain analogies between the behavior of plants and animals placed under abnormal environment, or under pathological conditions. These symptoms or habits are for the most part well known to specialists in either field, but their mutual relations are sometimes overlooked by both.

If two groups of organisms show fundamental similarities in development or behavior under normal conditions, we should naturally expect them to exhibit to some extent at least resemblances in their reactions to abnormal conditions.

When we contrast the bodies of higher plants and animals we are at first struck with the great differences in their anatomy. These differences *are* great, but the more closely we study them, especially in the construction of their constituent units, the individual cells, the more striking do their resemblances become. I shall later show a few concrete illustrations which will better bring out these facts, and for the present call your attention to the construction of the cell units composing typical higher plants and higher animals.

In the first place, every plant and every animal here under consideration begins life as a single cell, this cell formed by the union of two parent cells, the egg and the sperm. By cell multiplication the mature individual finally results as a community of co-operating units, only to repeat the process.

There are differences in structure between the cells of plants and animals, but these differences consist rather in their enclosing walls than in the essential living protoplast.

These structural units then, are quite similar in the two kingdoms: What about their separate functions and the combined functions of them all in the individual mature organism? I have already called to your attention the fact that their mode of reproduction, the exclusive act of two individual cells, is identical. The functions of an individual organism, however complex, can only be the sum of the functions of its component cells. We are not surprised, therefore, to find that access to water, for example, is a prime essential condition of life in both kingdoms. We may on first reflection argue that ordinary land plants require much more of it than the higher animals do. Further acquaintance with the facts, however, shows that another factor intervenes to bring about this apparently greater water requirement. The essential difference in fundamental life requirements of the green plant and the higher animal is that the plant is able to manufacture its own food through the energy supplied by sunlight. In order to accomplish this end the plant must provide for a relatively enormous access of air in order to get its required carbon dioxide, because this gas exists in but small quantity in the atmosphere. The plant thus has to open a large portion of its body and expose internal cells to the air. This subjects these cells also to water loss by evaporation which necessitates a constant current of water through the plant. Another factor tending toward the same result is the necessity for a large body surface exposed to the incident rays of sunlight, in order to secure the necessary energy for food manufacture.

The process of food digestion is practically identical in the two kingdoms. Both animals and plants require virtually the same kinds of foods. Nothing could be more convincing in this direction than that the two chief sources of bread for the human race, rice and wheat, consist mainly of carbohydrate and protein food stored up by the plant to nourish its young. The striking difference in relation to food between animals and plants is that green plants are able to manufacture their food from raw mineral materials, in other words, are autotrophic. This function, restricted to chlorophyll bearing plants, is special, and if we are to trust the conclusions of Macchiati may go on outside the organism from purely chemical solutions of chlorophyll in the presence of sunlight and carbon dioxide. It is true, also, that a comparatively small proportion of the cells of a higher plant contain chlorophyll, and the other cells of the individual have to be nourished in exactly the same manner as animal cells.

In like manner we find the respiratory function identical in the two kingdoms, in fact we may say that the liberation of energy by oxidation of combustible materials is about as nearly a phenomenon common to all living creatures as can be found.

If, then, we find that plants and animals reveal essentially the same fundamental structure, that they originate in the same way, that their essential vital functions are the same, we naturally should expect their behavior when exposed to abnormal conditions to be subject at least to the same general laws. In other words, we should expect striking analogies between animal and plant pathological phenomena.

When we attempt to compare the behavior of plants and animals under pathological conditions, we must at the outset be very cautious in assigning proper valuation to the great complexity of organization in the higher animals and to the high degree of specialization among their gross organs, their tissues and even their individual cells. A modern machine gun is a much more efficient weapon of offense or of defense than the old flintlock rifle used by Andrew Jackson at New Orleans; but the modern weapon could be rendered useless by a blow that would not in the least impair the performance of the simple and more primitive arm. Just one illustration serves to emphasize this point. In the higher animals there is no marked cellular response to the light stimulus except in a comparatively small group of cells contained in the visual apparatus which we call the eye. In most plants the greater part of the cells of the growing stems and leaves, and in some cases even the roots, are able to perceive the light. In other words, light perception is generalized in plant cells and loses in intensity. When from any pathological condition, traumatic or otherwise, the animal's eyes are destroyed, the whole body loses the power of response to the light stimulus. The plant cannot have its "eyes" destroyed without the total destruction of its body.

We are not surprised, therefore, to find a more striking ability on the part of a plant to repair an injury or to regenerate or replace an organ, and we find as we descend the animal scale this ability to regenerate an amputated organ increases. It seems in a sense remarkable that I have the third nail on one finger, it having been twice regenerated after having been broken out. A salamander would have grown out an entire arm or leg to replace the one amputated.

Thus we have in the plant scarcely a single vital organ in the sense meant by that term in human physiology. If you amputate the leaves, the stem and root survive and new leaves form. If you remove the root and place the stem under proper conditions a new root system will develop. You may even in some cases destroy both root and stem, and a new plant will grow out from the dentations of the leaf. All these facts must be given due consideration when we compare the pathological behavior of plants and animals. Especially must we remember the plant has no specialized nervous system, the power of response being shared almost equally by all its cells, though stimuli can be transmitted along definite directions in some cases.

When we examine the aetiology of plant diseases we find a predominance of those due to fungi. As a typical example of plant diseases due to obligate parasites of this class we may take the common rust of wheat. This disease while not usually proving fatal to the plant attacked, does often greatly impair the vitality of the host and result in greatly diminished harvests. The world's toll to this parasite has been estimated at a hundred million dollars annually.

Another interesting typical obligate parasite is the smut of corn. Infection may occur in this disease at any point of the host plant where active growth is in progress. The vegetative filaments of the fungus ramify sparsely through normal tissue of the host, and often cause no abnormal appearance until fruit begins to form. The enormous tumors produced by the rapidly dividing and growing cells of the host plant, filled with the powdery black mass of myriads of spores, are only too familiar objects in almost every corn field.

The production of tumorous growths is also well exemplified by the Exoascus species producing the disease commonly known as leaf curl of the plum and peach.

Other fungi not to be considered typical obligate parasites often produce most serious and destructive plant diseases. They seem to take advantage often of any mechanical injury caused by insects, for example, and attack the dead host cells as saprophytes. From an entrance thus effected, they advance into adjacent healthy tissues, destroying often an entire plant. They often become extremely virulent and are then able apparently to infect the host plant directly. To this class belong the various anthracnoses which are well exemplified by the clover anthracnose, which by a careful and very conservative estimate made a few years ago, was costing the State of Tennessee at least three million dollars annually.

Not many human diseases are caused by fungi, but a whole order of fungi, the entomophthorales, are for the most part parasitic on insects. The common Empusa muscae, a parasite of the house fly, is a good example of the latter. Actinomycosis, lumpy jaw of cattle, is one of the fungi known as pathogenic to man. The tumor-like growths caused by this parasite of cattle and men have a striking resemblance to fungus galls, or tumors, produced on plants.

Bacteria as productive of plant disease, were first recognized by Burrill, a veteran American plant pathologist, between 1877 and 1884 in the discovery of Bacillus amylovorus as the cause of pear blight. This organism ordinarily gains access to the tissues of the host through the blossoms. It is disseminated, as shown experimentally by Waite, mostly by bees visiting the flowers for nectar. It may be remarked, by the way, that this fact was brought out long before we had heard of insects as carriers of human disease.

Another and very different type of bacterial disease is the crown gall. The aetiology of this disease for many years baffled investigators, and it was not until 1904 that Dr. Erwin F. Smith, of the United States Department of Agriculture, almost accidentally found it due to a bacterium, which he named Bacterium tumefaciens. He was attempting to get cultures of microorganisms from the interior of a tumor, and while he found several forms developing in his cultures, none had proved to be pathogenic. Finally he happened to examine some discarded Petri dishes in which some ager cultures had been made from crown gall material, when he observed some newly formed, pale yellow colonies. These proved to be the organism producing the tumor, as shown by numerous cross inoculations among various species of plants. A striking point in connection with this organism is that it has rarely been found in preparations of gall tissue. This is explained on the supposition that there is here such a delicate balance between host and parasite that the bacteria are disintegrated almost as rapidly as they are formed. Dr. Smith has urged with a great deal of force the striking analogy between crown gall of plants and cancer of the human body, and one German investigator has gone so far as to attempt to show that the same organism may be responsible for both diseases. Smith calls the crown gall a plant cancer and has shown that, after making due allowance for the difference in anatomy and physiology of the plant and animal, every symptom and observed fact in the one case is true in the other, except that the causative organism has been discovered in the crown gall, and that therefore we may confidently expect the eventual discovery of a microorganism as the cause of human cancer. Smith reported in Science a few weeks ago that he has actually succeeded in producing tumors on plants by injecting extracts of the bacteria.

I need only in this connection remind you of the numerous bacterial diseases of the human body, such as typhoid fever, diphtheria, tuberculosis, etc., to convince you of the similarity of behavior of plants and animals toward this class of parasites.

A pathological condition manifesting itself as galls or tumors, caused by insects and other animals, is a matter of every day observation. Phylloxera of the vine, a destructive European trouble, and woolly aphis of the apple in this country furnish familiar examples. The question, however, has been raised here whether bacteria similar to the species causing crown gall may not be the real agent in producing these galls.

If I had the time to take up the behavior of plants and animals toward poisons, it could easily be shown that as a general fact the same substances are poisonous to organisms in both kingdoms.

As regards the general question of pathological anatomy, Kuster has shown in his pathologische Pflanzenanatomie, published in 1903, that the terminology introduced by Virchow many years before applies with scientific precision to abnormalities of plant structure.

We have now seen that plant and animal diseases show most striking resemblances in both their causes and effects. Let us now consider for awhile the mechanism by which representative organisms from the two kingdoms protect themselves against the attacks of various diseases.

In the first place, we find that individual plants of the same species show striking differences in disease resistance, and that in many cases at least this power of resistance is transmitted to the offspring, so that it often becomes a comparatively simple matter to produce by selection or breeding a variety resistant or immune to any particular disease. A number of important diseases of economic plants has already been controlled in this way. The anthracnose of clover just referred to is a striking example of this kind. A number of other similar instances might be mentioned, as the cow-pea wilt and cotton wilt by Orton, the tomato blight by Essary, and the flax wilt by Bolley. It has been shown that disease resistance of plants may be transmitted to the offspring in strict conformity to Mendel's law, thus placing the hereditary nature of the disease resistance beyond doubt. The same must be true in the case of animals, including man. If alternating columns of unvaccinated Mexicans and Anglo-Saxons should be equally exposed to a virulent type of small pox, a photograph of the columns similarly placed after the passing of the epidemic would very probably greatly resemble the clover experiment shown a moment ago. There is little doubt, however, that plant pathologists are inclined to lay more stress on heredity of immunity and susceptibility to disease than are human pathologists. A plant pathologist is then rather inclined to predict that in the next few decades the medical profession will lay more stress on heredity of immunity than they do at the present time.

In the study of the physiology of resistance and immunity the animal pathologists are far in advance of plant pathologists, thanks to the brilliant succession of researches led by Pasteur in the last century.

Let us for a short time consider some of these results. I have not, of course, the time or the knowledge of the subject to give you any other than a very inadequate survey of the question, and will only call your attention to certain phases of it.

To Metchnikoff is due credit for the discovery of phagocytosis, by means of which foreign bodies in the blood stream, such as pathogenic bacteria, are engulfed by an amoeboid movement of the white blood corpuscles and destroyed by a process of digestion not unlike the regular act of feeding by the one-celled amoeba. For some time this was thought to be the only means of defense against infection possessed by the human or animal body. It was soon found, however, that there are produced substances or bodies in the blood serum which are able to destroy bacteria or to render them harmless without the intervention of the phagocytes. It was also shown that the phagocytes themselves are often powerless to attack bacteria in the absence of certain specific sensitizers in the serum, called *opsonins*. Of the wonderful advance in medical science due to all these brilliant discoveries, to which Behring, Koch, Ehrlich, Wright, and others have contributed, the world knows.

To make a long story short, there are produced in some cases bodies that directly neutralize the toxic products of the bacteria, the toxins. These bodies are called anti-toxins. In other cases special serum constituents are found which attack the invading bacteria directly and destroy them. These were termed *bacteriolysins*. Certain other bodies exist in an immune serum, which are able to throw bacteria into clumps or adherent groups and render them harmless. These are called *agglutinins*. Another class of anti-bodies has been recognized in immune sera, which will precipitate homologous bacterial extracts and are called *precipitins*.

In some of the pathogenic bacteria the poisons constantly diffuse out into the medium. The diphtheria bacillus is a prominent representative of this class. Bacterial poisons of this kind are known as *exotoxins*.

In other cases, as in the cholera spirillum, the toxins are locked up within the body of the parasite and do not escape into the serum or medium until it dies. These are known as *endotoxins*.

Immunity may be acquired in several ways. The actual organisms in an attenuated form, or their toxins, may be injected into the blood of the patient. This causes the serum to respond by the formation of the specific anti-bodies, which thus render the patient immune. Or antibodies may be provoked in the serum of another animal as is done with the horse in the case of diphtheria, the serum from this animal then contains the antibodies and becomes an antitoxin, which may be used successfully in the treatment of the disease in question. It is very significant also that specific antibodies may be formed in the serum from the injection of minute doses of snake venom and of a number of other poisons, generally protein compounds. For the purposes of our discussion it is very significant that the symptoms of a disease are provoked by injections of the poisonous products of the causative organisms.

The question of the production of specific antibodies by plants has scarcely been touched upon by plant pathologists. The difficulties in the way of such investigations are readily apparent. There is no such thing as a "humoral fluid" in the plant body comparable to the blood serum of the higher animals, and if such reactions actually occur in plants the antibodies must be sought in the sap of individual cells. As a matter of fact, a young Austrian pathologist, R. J. Wagner, reported the discovery of antibodies in the potato, late in 1914. He records the occurrence of—

"1—Agglutinins, that is, bodies which retard flagellate movement."

"2—Lysins, which cause the cell walls of the bacteria to swell up and to pass into solution."

"3—Growth retarding bodies, which prevent the spores and thick walled bacteria from germinating."

"4—In the plant also occurs a concomitant, perhaps also an efficient factor, an increase in the acidity of the cell sap." He announces results to be embodied in a second paper showing "the possibility of active and passive immunization of plants and bactericidal bodies in them."

In a subsequent paper representing work done during recovery from a wound received on the "Northern battle front" Wagner discusses in detail the increase of acidity of the cell sap of plants, or of hydrogen ions, as a result of infection with bacteria. Von Fiegler had shown the same thing true of the blood serum of animals, as expressed by a lower degree of alkalinity following infection. Wagner regards this increase of acidity as a protective phenomenon. The same result occurs after wounds in plants, and by some investigators has been termed "wound fever." If Wagner makes good his claim there now remains virtually a single gap in the strict identity of response between animals and plants to agencies of disease. Does phagocytosis exist in plants? This question seems also capable of an affirmative answer. So far as I have been able to find, no one has reported such a phenomenon as the engulfing of bacteria by plant protoplasts. We must remember that there are no migratory cells in the bodies of higher plants, and that if phagocytosis exists, it must be found in the fixed body cells. We must remember, however, that there are fixed phagocytes even in the human body, and intracellular digestion is the rule in coelenterates.

In the first place there hardly seems any other explanation for Erwin F. Smith's results with crown gall. What becomes of the bacteria shown to be the cause of this disease if they are not disintegrated by some active agent; and what other process could better account for the phenomenon than phagocytosis? Phagocytosis in the root nodules of cycads has been shown by Zach, and in orchid roots by Bernard. In each of these cases the parasite was a fungus. This fungus is really symbiotic with the orchid, which under certain conditions seems to become antagonistic or pathogenic. Bernard found in many cases that the filament of the fungus clumped into balls, which phenomenon he even compared to agglutination of bacteria. He also found that after one infection of an individual orchid seedling, a subsequent infection could not be produced, in other words the plant was immune against a subsequent attack, as occurs in many human diseases. In this connection, some interesting results were secured last year by Mr. Haenseler, a graduate student in my laboratory. Convinced that a study of unicellular algae in their relation to fungus parasites should simplify the problem experimentally, I set him to work on Spirogyra and its parasites. His results were remarkable in that they indicated at least a suspicion of attempted phagocytosis in a unicellular alga, though it may prove to be an effort on the part of the spirogyra cell to thicken its wall against the invader, as Brullova found in the case of Vaucheria.

It is very significant that pathogenic organisms both fungi and bacteria lose greatly in virulence, for either animal or plant host, on being cultivated in artificial media.

It is very probable that if plant pathology is ever to repay its debt to animal pathology as the pioneer in the discovery of the essential principles of acquired immunity to disease, it will be in the direction of the cause of *cell resistance.* This is unquestionably the chief problem in hereditary resistance. The facility with which unicellular plants can be manipulated and observed experimentally should enable the subject to be approached from this direction with at least some probability of definite results.

All these facts brought out by the careful researches of modern biology serve to explain more and more thoroughly the details of the intense struggle for existence, in which every individual from the highest animal to the lowest plant must take part. Every individual is supplied with weapons of defence or of offence, some great and some small, and in this grim competition the race is not always to the swift or the battle to the strong.

FERNS FOUND IN THE VICINITY OF SEWANEE

BY JOHN T. MCGILL, VANDERBILT UNIVERSITY.

[Read before the Academy, May 4, 1917.]

"Gray's Manual of Botany," seventh edition, "A Handbook of Flowering Plants and Ferns," is limited to the flora of the eastern provinces of Canada and to that portion of the United States east of the 96th meridian and north of the southern boundary of Kansas, Missouri, Kentucky, and Virginia. Seven families of ferns are represented within this area. Omitting two of these comprising only three genera of insignificant aquatic plants, which embrace four species altogether, the remaining five families include twenty-four genera. Four of these embracing seventeen genera have been found within a distance of three or four miles of Sewanee, showing that this region—and perhaps other parts of the Cumberland plateau—is very rich in flora of this kind.

The following statement shows the number of genera and species found in each of the five families, in the area of the United States and Canada mentioned above and in the vicinity of Sewanee*:

Hymenophyllaceae in U. S. and Canada, 1 genus, 1 species; at Sewanee, 1 genus, 1 species.

Polypodiaceae in U. S. and Canada, 18 genera, 58 species; at Sewanee, 14 genera, 27 species.

Schizaeaceae in U. S. and Canada, 2 genera, 2 species; at Sewanee, 0 genera, 0 species.

Osmundaceae in U. S. and Canada, 1 genus, 3 species; at Sewanee, 1 genus, 2 species.

Ophioglossaceae in U. S. and Canada, 2 genera, 9 species; at Sewanee, 1 genus, 1 species.

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*Doctor McGill used in presenting the paper lantern slides made recently from specimens of all the species of ferns which he had collected at Sewanee nearly thirty-six years previously. The specimens had been remarkably well preserved, as indicated by the pictures.—Ed.

It is probable that the "climbing fern," *Lygodium palmatum* of the family Schizaeaceae, grows on the Cumberland plateau. I have a specimen that was brought from Kentucky.

During a visit to Sewanee in the summer of 1881, extending from July 15 to August 15, I made a collection of the ferns enumerated in the list here appended, with the exception of two, *Woodsia obtusa* and *Asplenium Ruta-muraria,* which General Kirby-Smith, then a professor at Sewanee, said grew in that vicinity. General Kirby-Smith had in his collection at that time specimens of all the ferns of the list here given except one, *Onoclea sensibilis,* I believe.

HYMENOPHYLLACEAE (Filmy Fern Family)

Trichomanes. Filmy Fern. Found on damp rocks under cliffs.
Boschianum (radicans, Gray's Manual, edition 6).

POLYPODIACEAE (Fern Family)

Polypodium. Polypody
vulgare
polypodioides (incanum)

Phegopteris. Beech Fern
hexagonoptera

Adiantum. Maidenhair
pedatum

Pteris. Brake or Bracken
aquilina

Cheilanthes. Lip Fern
lanosa (vestita). Not mentioned for this region by Gray.

Pellaea. Cliff Brake
atropurpurea

Asplenium. Spleenwort
pinnatifidum

Trichomanes. Maidenhair Spleenwort
parvulum
platyneuron (ebeneum). Ebony Spleenwort
montanum. On rocks and cliffs.
Ruta-muraria. On limestone rocks (General Kirby-Smith)
angustifolium
acrostichoides
Filix-femina (Lady Fern)

Camptosorus. Walking Leaf
rhizophyllus

Polystichum
acrostichoides (Christmas Fern)
Aspidium. Shield Fern. Wood Fern
Thelypteris
noveboracense (New York Fern)
marginale
Goldianum (Goldie's Fern)
Cystopteris. Bladder Fern
bulbifera
fragilis
Woodsia.
obtusa
Dicksonia. Dickson's Fern
punctilobula (Hay-scented Fern)
Onoclea.
sensibilis (Sensitive Fern)

OSMUNDACEAE (Flowering Fern Family)
Osmunda. Flowering Fern
regalis (Royal Fern)
cinnemomea (Cinnamon Fern)

OPHIGLOSSACEAE (Adder's Tongue Family)
Botrychium. Moonwort
virginianum (Rattlesnake Fern)

WILD FRUITS OF TENNESSEE

BY ROBERT SPARKS WALKER, EDITOR SOUTHERN FRUIT GROWER

[Read before the Academy, May 4, 1917.]

I have a vivid recollection today of the many times when a boy, on Christmas mornings, of going to the fireplace and emptying the contents of the sometimes sparsely filled stocking out on the floor. The candy, apples, fire crackers, and nuts were all carefully separated. Among the nuts were often represented a number of varieties, and the filberts, pecans, Persian walnuts, Brazil nuts, and almonds were all gathered together, each in its particular class. Of the lot, the almonds were the last to be eaten, and well enough that it was so, for in no uncertain or mild terms did we condemn the person, firm or corporation, unknown to us, who was so grasping as to palm off peach seed on innocent children under the guise of almonds. Our parents, feeling the same about the perpetration of the supposed fraud, by their silence approved of the scathing denunciations. In after years, when we learned that the almond and peach were true brothers of common parentage but with talents developed in different commercial channels, one being educated for its kernel with neglect for the pulp, and the other vice versa, it was with no little regret that we looked back upon our ignorance and wished that we had then had some one to enlighten us and thus not only save us from the useless condemnation of an imaginary fraudulent person, but, being of a daring disposition, might have caused us to accept the challenge of nature. As a result of such enlightenment and inspiration we might have accepted the challenge then thrust out before us in the form of wild fruits of Tennessee inviting, nay, daring men to improve them.

In taking up this subject of the "Wild Fruits of Tennessee," at the beginning I must say that it is useless as it is impractical for me to undertake to give attention to each species. Those that I mention shall be in order of their importance, as I regard them.

The Native Persimmon.

Being equaled in food value by one other fruit, and that the date, I must place the native persimmon (Diospyros Virginiana) first. Fortunately, the persimmon thrives over the greater parts of the State of Tennessee. The native persimmon offers a challenge to ambitious plant breeders for improvement, and the persistence of the plant to grow in almost any kind of soil, and its ability to produce abundant and regular crops, make it a most desirable fruit, yet it must be admitted that it has been sadly neglected. The persimmon is found growing wild as far north as 38 degrees latitude, yet it is known that it will thrive and ripen its fruit as far north as the Great Lakes. Of the fourteen wild varieties, the most of which are found growing in Tennessee, it is claimed that six originated in Indiana, four in Missouri, one each in Illinois, Kentucky, Mississippi, and Pennsylvania. When the varieties receive more attention in the future, other varieties will be added to the now small list. In this State, the erroneous impression has gone abroad that the persimmon is unfit for food until the frost has fallen on it. I have been observing different varieties for over ten years, and the one that I consider the best ripens its large oblong fruit in early August. Other varieties follow until the tenacious ones (which are usually marked with a great degree of astringency) hold on with a tight grip until they are eaten by boys, birds or wild animals in the dead of winter.

Persimmons are easily propagated from seed, in the same manner as peach trees, but as the varieties will not come true, they must be either budded or grafted. The native persimmons of Tennessee are easily top-worked with the Japanese persimmon. I know a man in Knox County who has been quite successful, and the large luscious persimmons that he produces on our native trees are equal to any in size or flavor that are produced anywhere in the extreme South. In Tennessee, the size of the tree depends entirely upon the variety and soil. (The tree is a difficult one to transplant on account of its large tap-root.) Trees in our State grow anywhere from 15 to 80 feet in height, but from my own observation, I have noticed that the smaller trees, or those ranging from 15 to 30 feet in height, are the heaviest and most regular bearers. As a food for the human family, the persimmon should take an important place. It is not generally known that from this fruit may be made most delicious ice cream, candy, cake, and bread. It may be used in various other useful ways.

THE ELDERBERRY.

The common elder (Sambucus Canadensis) of the United States, I believe holds the second greatest possibility for development into a valuable domestic fruit. The ability of the tree to produce fruit in almost any kind of soil, its rapid growth, and its lateness of bloom are all that could be desired.

For the very reason that a plant is common, and grows and thrives in every locality, its valuable qualities are often overlooked, and it therefore by its prominence is concealed from investigation and barred from development. I have been acquainted with elders and elderberries from childhood, but not until after I reached thirty years did I really see in it its fine qualities. It came about in this way that I was attracted to it: One year the freezes had killed all the cultivated fruits, and on the fourth of July, while out driving with my family, I was astonished to find the elders then in bloom. That year I had a few transplanted to my garden, and I have grown them for the last seven years. The second year I tried crossing this plant with others, but owing to the lateness of the blooming period, I found it difficult to save the pollen dust from other plants which preceded the elder in blooming some two or three months. We dried the pollen of other flowers but it would mould. But we eventually succeeded in keeping pollen by this method: After the pollen was shaken off on some smooth surface like paper or glass, it was set in the shade to dry. Too much sunlight impairs its vitality. When it had thoroughly dried in the shade it was put into dry bottles, then sealed and corked. In this manner I have been able to keep pollen for crossing, three months or longer if desired.

I found that the judicious pruning of the elder plants annually produced good results, and, for young bushes, if they are cut two or three feet from the ground, each stem will make from two to four branches and each of these will bear a large clump of berries. By proper pruning and cultivation of the plants, the berries produced were of a larger, richer color, and remained on the bushes until after the frost. The flavor was so much improved that we could eat these raw berries as they came from the trees. The fruit also made the best pies, which were as highly prized as those made from the huckleberry. I regard the elderberry a splendid wild fruit of Tennessee that offers a challenge to plant breeders, which I hope will soon be accepted by some ambitious person.

The Passion Fruit.

We have just about fifty species of the passion flower (Passiflora) growing in America, but in Tennessee the most common is the passiflora incarnata, the fruit of which is called by natives May-pops or apricots. The passion fruit is another plant of rapid growth, and very productive. In Australia it has already entered into the channels of commerce, but with us it is left still to ramble over old fences, brush piles, and to add cheer to our many neglected fields. For years, though, this fruit has been used by a few Tennesseans for making jellies and a few other household dainties. The passion fruit has many valuable qualities, and, like the fig, ripe fruit and blooms may be found simultaneously on the same plant. When the fruit ripens the pulp becomes shriveled and flabby and is at this time quite aromatic. It offers two ways of propagation, either by seeds or by cuttings.

The Apios Tuberosa.

My attention was first directed to the apios tuberosa by Mr. Luther Burbank, three years ago, when I had invited him to visit me in Chattanooga. In his acknowledgment of my invitation, he stated that he was quite anxious to come, for he wanted very much to find the apios tuberosa, a very rare plant, we had growing here in abundance. Upon receipt of this letter, I immediately laid my plans to capture a few of these Indian potatoes or ground nuts as they are sometimes called. As I was depending on the blossoms to be my guide in locating it, I found they did not bloom until August and September. In vain I searched moist places for three years; the nearest thing like it I could find was the wild or hog peanut. But my efforts in August, 1916, were rewarded with success. At that time the specimens I found were growing in a moist meadow near a brook. The tubers were very soft, nutty, and rich. The apios undoubtedly produces one of the most beautiful flowers, being of a maroon and pale brown lilac color. The plant climbs and twines about weeds and bushes. The apios tuberosa is not a fruit, but rather than neglect mentioning it as one of the promising wild plants for the possibilities it holds for the development of its tubers, I have stepped beyond the subject assigned me today in order to here make mention of it.

The Farkleberry (Batodendron Arboreum).

I know that this berry is familiar to every Tennessean who has spent only a few hours rambling the woodlands, whether it be a valley, a hill, or mountain top, for I have found it growing at all altitudes in the State. This berry is known by Tennesseans as the winter huckleberry. It grows on bushes that range in height from 5 feet to 25 feet, but the maximum given here is uncommon. They are usually found in vacant spots in the woodland, and often a "patch", covering from a quarter to a half acre, will be observed. This farkleberry is closely related to the blue berries and huckleberries, but its ability to withstand the frost and freezes without impairing the quality of the fruit makes it a most remarkable wild fruit and a very valuable one. In January, 1913, I had the pleasure of directing the botanist of the United States Department of Agriculture to this plant and its merits. At that time our Government botanist admitted that he was not aware of the fact that the berries of any variety of the farkleberry remained so long on the trees. The fruit is of a dark color, spherical in shape, and is ready to eat about the first of November. It clings to the bush throughout January, February, and I have gathered a few of the delicious berries as late as the middle of March. The plants are usually heavy and regular producers, and the fruit possesses meritorious qualities that place it in the list of valuable wild fruits of Tennessee.

The Huckleberry (Gaylussacia).

On the mountains and hillsides, the huckleberry is a familiar fruit to each of us. In the wild and shaded spots of these woodlands this wild fruit, which is so highly prized, is found growing in abundance. It has been demonstrated that huckleberries may be grown successfully, but the first requirement is an acid soil. I know a few people in Tennessee whose efforts have been unsuccessful, from the fact that the huckleberry plants were not set in soil that had an acid content.

The Muscadine.

These wild grapes found growing in Tennessee are not well known to inhabitants in the northern United States. The name muscadine is probably derived from the word muscadel, meaning like a nutmeg, or smelling like a musk. In the southern United States, south of 36 degrees latitude, the muscadine (rotundifolia) holds sway along the ravines, running brooks, creeks, and rivers. In this very small group of large wild grapes, consisting of about eight varieties, only a few of them have worked their way into cultivation and propagation. In all probability, a few of these vines may be found growing and fruiting in farmable sections a bit farther north than 36°, particularly near the North Carolina border. But it may be safely said that the best region for growing the muscadine grape is in the cotton belt of the United States.

These grapes are quite round, all with very tough skins, yet have a very fine flavor and one that is liked by all.

Since the most of the muscadines have a very tough skin, they are not attacked by many insect pests. Neither do the birds bother them. The vines are fast growers, very hardy, usually of a tough growth, and are practically free from disease. The vines in a wild state in Tennessee have stood a freeze at least 10° below zero. They are easily grown, but thrive best in moist, sandy soil. Along rivers and other running streams, in a wild state they are found growing to perfection. In the month of September thousands of fine, rich, black muscadine grapes may be seen continually floating down the streams. The vines like to ramble, and climb trees sometimes a hundred feet in height. So many trees inclined over running water have been infested by thrifty muscadine vines that hundreds of bushels of muscadine grapes are carried away each year by running water. In the valleys, on the hillsides, and on the mountain tops along the creek banks, the muscadines revel in vigorous growth, producing crops every year. The lateness of blooming is responsible for the regular crops of fruit.

Inasmuch as the muscadine is so easily transplanted, I hope that I may be pardoned for taking up the time to give a little information as to how it may be done.

They may be propagated by cuttings or layers. The latter method is by far the better plan. By the former method, cuttings should be made a foot long and placed in the ground at an angle of about 45°, with about half of the cutting above the ground. This should be done in the latter part of October, or during the month of November. But, where only a small number of vines are wanted, the layering is the best method of propagation. In the early spring, select a good cane of the previous season's growth and lay it down into a trench about 5 inches deep and 2 feet long. Pack the soil tightly about the vine, for about 2 inches, then fill with loose soil. Leave from six to eight inches of the end of the vine exposed to the air. By fall, at all joints, roots will have appeared and the layer may be cut from the parent vine and transplanted. These should by all means be transplanted in early fall, and if they are set for an arbor, they should be set from 30 to 35 feet apart. If they are planted for trellis training, the rows should be twelve feet or a little more apart and the plants set about 30 feet apart in the row. It will thus be seen that only a very few plants will be required to set an acre. The newly set vines should be pruned back so that only about 6 inches is left in the soil and about 5 inches on the outside. It should be born in mind that as the muscadine favors soil well supplied with moisture, that a mulch of some kind, especially of decaying leaves, will make plants more vigorous as well as productive. They are fast growers and require much room. In the after pruning of the muscadine, the proper time for the work is during the months of October and November. They seem to be more inclined to bleed than other varieties and any pruning given in other months causes a loss of vitality through the bleeding process, which requires months for the weakened plant to regain. They should never be permitted to grow in a mass, but should be kept pruned so the vines may have plenty of room, sunshine, and air. This insures a big crop of large fruit.

Why Some Vines Do Not Fruit.

On many farms as well as in the forest, are to be found fine healthy vines, which bloom, but never fruit. Owners as a general rule do not understand this apparent mystery. It should be borne in mind that all fruiting varieties of the rotundifolia or muscadine grape are imperfect bloomers. This necessitates the planting of staminate varieties of the same species nearby for fertilization. One staminate vine will produce enough pollen to perfectly fertilize eight bearing or pistillate vines.

The muscadine grape certainly merits attention. A very few people of late years have realized its value, and are giving it cultural attention. Its habit of being a regular bearer, large fruit, of peculiar but pleasant flavor, merits for it a permanent place on every farm. It is not at all improbable that it will work its way more prominently into the channels of commerce in the future.

The Blackberry.

Some years ago I made the statement that "Nature never does for a man that which he is able to do for himself." The blackberry (Rubus triviallis), I must admit, is one of our most important wild berries in Tennessee, but from its persistence in declaring my statement untrue, I have spitefully classified it as a "fugitive from justice." In the wild state this berry has entered the channels of commerce, and is of the utmost economic importance to the people of Tennessee, but inasmuch as it has already been domesticated I have let other varieties of wild fruits take precedence.

The Papaw.

In many localities of Tennessee, on creeks and river bottoms, is found growing the papaw (Asimina triloba), which is so highly prized as a fruit. I have observed a few papaw trees which have been transplanted and cultivation given, and these have been successful, where particular regard has been given to the selection of the proper soil. In growing this wild fruit, which has to a very limited extent worked itself into the market, soil means everything to the success of the tree.

The Service-berry.

This is one of the wild fruit-bearing trees of our State that is rarely ever found growing excepting on the banks of streams or on overflow soil. The service-berry (Ameliancher Canadensis) belongs to the natural order of Rosaceae. The tree is bushy and is also known by the names of Juneberry, or shadbush. The fruit is red, varying in size from a current to that of a Morello cherry, and ripens in June in Tennessee. It is easily propagated from seed or by cuttings or layers in the fall. I have observed that in Tennessce the young trees may be easily transplanted to farmsteads, and, if given attention, produce an abundance of berries. The name shadbush is given this tree because the blossoms appear about the time that shad begin to ascend the rivers in spring time.

Tupelo.

The two varieties of Tupelo, found growing in Tennessee, the Nyssa Multiflora (black gum), and Nyssa Aquatica (cotton gum), produce an abundance of olive-shaped fruit which have so far received little or no attention. Honey producers have pushed the sale of Tupelo honey into the markets so vigorously that the word "Tupelo" now is a common one where honey is sold. When the first French settlers came to America, they preserved the fruit of the Tupelo in the same manner as they did olives. I believe that the large crops of the Tupelo fruit will eventually be conserved. I venture the estimate that in the year 1915, when there was the most abundant crop of Tupelo fruit, that the quantity that went to waste, had it been preserved, would have been sufficient to supply the people of this State with a substitute for olives for three years.

The number of wild fruits growing in Tennessee is so large that it is impossible for me to mention all of them. I have only mentioned a few of the most prominent ones. There are many other kinds of wild fruits, serving in their present state of development as food for birds and wild animals, some of which should in the future, if man can be relied upon to do his duty, contribute to the welfare of humanity.

SOME FLOWERS OF MIDDLE TENNESSEE

BY JESSE M. SHAVER, GEORGE PEABODY COLLEGE FOR TEACHERS

[Read before the Academy, May 4, 1917.]

I have often felt that there was a definite need on the part of botany teachers, nature-study teachers, and the general public for a listing or arrangement of the flowering plants according to distribution and time of flowering. Most people do not have the time or perhaps the knowledge to wade through Gray's Manual or other key in order to find out the name of a flower.

For these people, therefore, I have attempted to arrange the flowering plants that I have observed in Middle Tennessee according to their time of flowering.

Very early in February, we notice the yellow flower heads of those persistent lawn pests, the Common and the Red-seeded Dandelions intermingled with the tiny white flowers of the Common Chickweed. By Washington's Birthday some of the early woodland flowers are peeping from under the leaves. The Harbinger of Spring with its low, inconspicuous umbers, and the Toothwort with its showy clusters of pinkish, white flowers, are found well protected in some dense ravine. But these are all of the flowers that we can find now, these "harbingers of spring."

In March, however, quite a number of our old favorites appear. In the damp woodland are somber-hued Trilliums, Celandine Poppies with their delicate crepe-like petals and sifter-like seed pods, and, best loved of all, the Bloodroot with its pure waxy-white petals. If we are sharp-eyed, we may find the low, delicate, white flowers of the Bitter Cress growing in siliceous soil. Perhaps we notice the heart-shaped rhizomes borne on or near the surface of the ground. If we should look for flowers by the stream that flows through the pasture, we would probably find Gill-over-the-ground forming a dense, low mat of green dotted with blue flowers, under the shade of a tree. In the shady, upland of the pasture, the slender, lance-like leaves of the Spring Beauty, with already a few flowers of white and pink, seem to be abundant, while in the cultivated fields and in the lawns, the Dead Nettles are successfully coping with the Chickweed.

But April showers are coming to awaken the sleeping beauties. The sly Violet slowly pushes itself out from its coverlet of leaves and, bashfully hanging its head, peeps around to see whether its cousins, the White Violet, the Yellow Violet, or the Wild Pansy have awakened yet. The Yellow Fumitory, not being so bashful, holds her yellow head up proudly above her lacy leaves. She is not ashamed of being a woodland flower. Bold and sturdy stands Jack in the Pulpit nearby. The little Rue Anemone lives in the shelter of a ravine, but other plants love the banks of the more open meadow streams. There the waxy, yellow spots in the grass show where the Buttercup has caught the gold of the sunbeam in its chalice. The little tiny-flowering Draba Verna strives to find some uncaptured sunbeams in its grassy home. Many dainty inconspicuous flowers are passed over unnoticed or disdainfully called weeds. Among these outcasts, Spreading Chervil and Corn Cromwell prefer the edges of cultivated fields, while the Small-flowering Buttercup prefers the lawns or woods.

By the middle of April, Shepherd's Purse appears in the meadows and lawns, and May Apples in the woodland with their waxy-white flowers hidden under their leaf umbrellas, contrasting with the small, unprotected flowers of Nemophila. Blue bells and Blue Phlox now have largely taken the place of the Rue Anemone and Bloodroot in the damp woodland and blue Phacelias and False Wild Onions have taken possession of the rocky glades. The tiny, pinkish-white flowers and long, slender seed pods of the Cranebill are now becoming plentiful on the lawns. The Early Saxifrage and Stonecrop in the crevices of rock ledges help to beautify and prepare a foothold for other plants. Certain of our early spring flowering plants are restricted to the siliceous soil of the hill tops. The sticky, red flowers of the Catchfly, the large blue and purple Bird's Foot Violet, the delicate little Bluett, the fragrant trailing Arbutus, the white, and pink, and red Azalias (wrongly called honeysuckles by the mountaineers), and the Wild Columbine are the most interesting of these. But perhaps the most beautiful of our spring flowers is that group that grows best in damp, rich woodland. The white Shooting Star, Jacob's Ladder, Dutchman's Breeches, and the Large-flowering Trillium all belong here. We find the Blue Oxalis in more open, dry woodland, but generally not in as dry, rocky places as the Lousewort, nor in as damp situations as the Smooth Oxalis. Bur clover is common as a weed in our lawns and in dry pastures, frequently being found associated with Milk Vetch, Pitcher's Sandwort and Psoralea in dry, rocky glades.

Many of these April flowers continue blooming in May, but many new ones appear, for May is pre-eminently the month of flowers. The tall, slender Wild Hyacinth with its long racemes of blue flowers and the Large-leaved Waterleaf are found near streams. Both the large White and large Yellow Evening Primroses brighten the fields in May. Corn Cockle grows in the grain field to the same height as the grain. The little Blue-eyed Grasses are of about the same height as Blue Grass, but seem to prefer a moister soil. Its tiny blue flowers are a surprise and delight. The low, blue clusters of the Dwarf Larkspur and the tall raceme of the Wild Comfrey brighten the woodland, while less conspicuous plants, such as the Mouse-eared Chickweeds and Corn Speedwell, take charge of the fields. Pepper Grass and Rib Grass (neither one a grass), help Dandelions and Shepherd's Purse out in trying to capture the lawn. Goose Grass with its tiny prickles climbs up among the Spreading Chervil of the hedges and fields. It is interesting because of its square stem and whorled leaves. And then the old Life-everlasting begins to flower everywhere.

But a change in the character of the flowers begins to make itself felt during the last two weeks of May; the composites begin to increase in number rapidly. The False Dandelion, Yarrow with its finely dissected leaves, Meadow Salsify with its long, slender, lily-like leaves, the Ox-eyed Daisy, now ranked as a very troublesome weed, the White Top of the meadows, the Dog Fennel and Sow Thistle of old fields and waste places are typical representatives.

That serious clover pest, Dodder, now is in flower. Corn Salad, Round-leaved Mallow, Venus, Looking Glass, Yellow and White Moth Mullein, Hedge Mustard, Yellow and White Sweet Clover, Spring Avens, several varieties of Larkspur, Horse Nettle, False Cromwell, Ruella, Yellow Dock, Sour Dock, Hedge Bindweed, Blue Blindweed, Prickly Pear, Clammy Ground Cherry, and Queen Anne's Lace are all plants of the field or open, rocky glades. Two of the prettiest flowers of the field are the beautiful Red Champion and the White Champion. Dutchman's Pipe is rather rare but sometimes found on river bluffs. In moist woodland, grow Solomon's Seal, the Lily of the Valley, Indian Pink, and the Wild Comfrey.

The Mountain Laurel crowns the tops of the high hills where the soil is siliceous.

And now, in closing, perhaps it would not be amiss to tabulate, for more ready reference, the information contained in these pages.

FLOWERS BLOOMING IN FEBRUARY.

YELLOW FLOWERS.

Common Name	*Technical Name*	*Kind of Soil*
Common Dandelion	(Taraxacum officinale, Weber)	Lawns and meadows
Red-seeded Dandelion	(Taraxacum erytrospermum)	Lawns and meadows

WHITE OR WHITISH FLOWERS.

Common Chickweed	(Stellaria media)	Lawns, pastures and fields
Tootworth	(Dentaria diphylla)	Shady, damp woods
Cut-leaved Tootworth	(Dentaria laciniata)	Shady, damp woods
Harbinger of Spring	(Erigenia bulbosa)	Shady, damp, woody hillsides

FLOWERS BLOOMING IN MARCH.

BLUE OR BLUISH FLOWERS.

Ground Ivy	(Nepeta hederaceae)	In shady spots on lawns and banks of streams
Dead Nettle	(Lamium amplexicaule)	Lawns, pastures and old fields.
Sessile Trillium	(Trillium sessile)	Rich woodland
Green Trillium	(Trillium viride)	Rich woodland

WHITE OR WHITISH FLOWERS.

Spring Beauty	(Claytonia virginica)	Dry open hillsides and woodland
Purple Cress	(Cardamine douglassi)	Wooded hillsides
Bloodroot	(Sanguinaria canadensis)	Rich, damp woodland
Bitter Cress	(Cardamine pennsylvanica	Meadows

YELLOW FLOWERS.

Celandine Poppy	(Stylophorium diphyllum)	Shady ravines

FLOWERS BLOOMING IN APRIL.

BLUE OR BLUISH FLOWERS.

Common Name	Technical Name	Kind of Soil
Dooryard Violet	(Viola domestica)	Lawns
Blue Marsh Violet	(Viola cuculata)	Lawns
Jack in the Pulpit	(Arisaema triphyllum)	Woodland
Virginian Cowslip	(Mertensia virginica)	Rich, moist woodland
Blue Phlox	(Phlox divaricata)	Rich, moist woodland
Phacelia	(Phacelia dubia)	Open woodland
Fimbriate - petaled Phacelia	(Phacelia purshii)	Open woodland
Bird's Foot Violet	(Viola pedata)	Open siliceous hillsides
Bird's Foot Violet	(Viola pedata, bicolor)	Open, siliceous hillsides
Bluetts	(Houstonia caerulea)	Near the banks of streams in siliceous soils
Blue Oxalis	(Oxalis violacea)	Woodland
Psoralea	(Psoralea subacaulis)	Rocky glades
Milk Vetch	(Astralagus tennesseensis)	Rocky glades

WHITE OR WHITISH FLOWERS.

Common Name	Technical Name	Kind of Soil
Wild Pansy	(Viola rafinesquii)	Lawns and fields
White Violet	(Viola striata)	Edges of fields and woodlands
Draba	(Draba verna)	Meadows
Spreading Chervil	(Chaerophyllum procumbens)	Fields
Corn Crowell	(Lithospermum arvensis)	Fields
Rue Anemone	(Anemonella thralictroides)	Damp woodland
Sheperd's Purse	(Capsella bursa-pastoris)	Lawns and fields
May Apple	(Podophyllum peltatum)	Rich hillsides
Small -flowering Nemophila	(Nemophila microcalyx)	Wooded hillsides
False, Wild Onion	(Noxhoscordium bivalve)	Rocky glades
Cranebill	(Geranium carolinianum)	Lawns and fields
Early Saxifrage	(Saxifraga virginica)	Rock ledges
Stonecrop	(Sedum ternatum)	Rock ledges
Trailing Arbutus	(Epigaea repens)	Siliceous hillsides
Azalias	(Rhododendron nudiflora)	Siliceous hillsides
White Shooting Star	(Dodecatheon media)	Rich woodland
Jacob's Ladder	(Polemonium repens)	Rich woodland
Dutchman's Breeches	(Dicentra cucularia)	Rich woodland
Large-flowering Trillium	(Trillium grandiflorum)	Rich woodland
Pitcher's Sandwort	(Arenaria patula)	Rocky glades

YELLOW FLOWERS.

Common Name	*Technical Name*	*Kind of Soil*
Marsh Buttercup	(Ranunculus septrionales)	Meadows
Yellow Violet	(Viola pubescens)	Woodland, fields
Yellow Fumitory	(Cordalis flavula)	Open woodland
Small-flowering Buttercup	(Ranunculus abortivus)	Lawns and meadows
Yellow Wood Sorrel	(Oxalis corniculata)	Lawns and fields
Nashville Yellow Mustard	(Lesquerella lesquerii)	Lawns. Abundant
Lousewort	(Pedicularis canadensis)	Siliceous hilltops
Smooth Oxalis	(Oxalis stricta)	Moist woodland
Yellow Trefoil	(Medicago lupuminus)	Lawns and meadows

RED FLOWERS.

(Most pink flowers were grouped under white flowers).

Catchfly	(Silene virginica)	Siliceous soil
Wild Columbine	(Aquelegia canadensis)	Bluffs and rocky ledges

FLOWERS BLOOMING IN MAY.

BLUE OR BLUISH FLOWERS.

Wild Hyacinth	(Camassia esculenta)	Along streams
Giant Waterleaf	(Hydrophyllum appendiculatum)	Along streams
Corn Cockle	(Agrostemma githago)	Cultivated fields
Blue-eyed Grass	(Sisyrinchium augustifolium)	Damp spots in the lawn and pasture
Dwarf Larkspur	(Delphinum tricorne)	Wooded hillsides
Corn Speedwell	(Veronica arvensis)	Lawns and pastures
Wild Comfrey	(Cynoglossum virginianum)	Rich woodland
Venus Looking Glass	(Specularia perfoliata)	Lawns.
Larkspur	(Delphinum consolida)	Waste places and rocky glades
Ruellia	(Ruellia ciliosa)	Rocky glades
Blue Bindweed	(Solanum dulcemara)	Waste ground
Dutchman's Pipe	(Aristolochia tomentosa)	Rare. River bluffs
Wild Comfrey	(Symphytum officinale)	Rich woodland

WHITE OR WHITISH FLOWERS.

White Evening Primrose	(Oenothera speciosa)	Waste places. Escaped
Mouse-eared Chickweeds	(Cerastium vulgatum, viscosum, nutans, and longipedumculatum)	Fields

Common Name	Technical Name	Kind of Soil
Philadelphia Fleabane	(Erigeron philadelphus)	Fields and lawns
Pepper Grass	(Lepidium virginicum)	Lawns and fields
Rib Grass	(Plantago lanceolata)	Lawns and fields
Goose Grass	(Galium asparine)	Edges of fields in damp places
Plantain-leaved Everlasting	(Antennaria plantaginifolia)	Siliceous soil
Yarrow	(Archillea millifolium)	Fields
Ox-eye Daisy	(Chrysanthemum leucanthemum)	Fields
White Top	(Erigeron annus)	Fields
Dog Fennel	(Anthemus cotula)	Old fields
Sow Thistle	(Sonchus asper)	Fields
Dodder	(Custata sp.)	Clover fields and waste lands
Corn Salad	(Valerianella radiata)	Fields
Round-leaf Mallow	(Malva rotundifolia)	Waste places
White Moth Mullein	(Verbascum blattaria var. albiflorum)	Fields
White Sweet Clover	(Mellilotus alba.)	Roadsides
Spring Avens	(Avens vernum)	Open woodland
Horse Nettle	(Solanum carolinense)	Waste ground
False Cromwell	(Onosmodium molle.)	Rocky glades
Yellow Dock	(Rumex crispus)	Waste places, roadsides
Hedge Bindweed	(Convolvulus arvensis)	Waste places
Clammy Ground Cherry	(Physalia heterophylla	Old fields
Queen Anne's Lace	(Daucus carota)	Old fields
White Champion	(Lychnis alba)	Fields
Solomon's Seal	(Polygonatum commutatum)	Rich woods
Lily of the Valley	(Convallaria majalis)	Rich, damp woodland
Mountain Laurel	(Kalmia latifolia)	Ravines and hillsides, siliceous soil

YELLOW FLOWERS.

Yellow Evening Primrose	(Oenothera triloba)	Fields
False Dandelion	(Krigia dandelion)	Old poor fields
Meadow Salsify	(Trogopogon praetensis)	Lawns and fields
Yellow Moth Mullein	(Verbascum blattaria)	Lawns and fields
Hedge Mustard	(Sisymbrium officinale)	Lawns and fields
Yellow Sweet Clover	(Mellilotus officinale)	Roadsides and waste places
Prickly Pear	(Opuntia opuntia)	Rocky glades

RED FLOWERS.

Sour Dock	(Rumex acetocella)	Poor, acid soil
Red Champion	(Lychnis dioica)	Fields
Indian Pink	(Spigellia marilandica)	Woodland

RESEARCHES ON DISEASE RESISTANCE IN RED CLOVER: PRELIMINARY REPORT.

BY SAMUEL M. BAIN, UNIVERSITY OF TENNESSEE.

(Abstract.)

There is a great contrast in the behavior of resistant and non-resistant strains of red clover toward the anthracnose, caused by Colletotrichum Trifolii. Selections made at the Tennessee Station in 1905 have transmitted their resistant character to their offspring under field conditions continuously since.

Preliminary results have been obtained this year which indicate that this resistance is due at least in part to the chemical characteristics of the cell contents. Spores of the fungus causing the disease were placed in hanging drop cultures in contact with fresh sections of the stems of races of known resistant or non-resistant character. While often no distinct differences would appear in the rate of growth of the mycelium, and occasionally even contradictory results would appear, in the majority of instances the spores growing in sterile water in contact with stem sections of resistant plants showed retarded growth as compared with those growing in contact with non-resistant stems. In some instances the difference in rate of growth amounted to as much as 300 per cent in the average of a series of cultures.

November 27, 1914.

OBSERVATIONS OF MARS AND JUPITER DURING THE 1914 OPPOSITION OF THESE PLANETS.

BY LATIMER J. WILSON.

(Abstract.)

Discusses the phenomena preceeding and following the summer solstice in the northern hemisphere of Mars. Evidence of cloud, snow, and frost in sub-arctic regions. The re-formation of the

southern polar cap generally masked by clouds over the entire region. The dark blue band around the melting northern cap and its probable significance. Illustrated with lantern slides.

Jupiter and the changes in its northern equatorial belt as compared with the same latitudes in 1912-13. The drift of light and dark spots, and what may be the cause of their peculiar motion. Illustrated with lantern slides.

November 27, 1914.

GALLS AND GALL-PRODUCING INSECTS.

BY ROBERT S. WALKER.

(Abstract.)

Illustrates how galls are formed on Spanish oak, black jack, and blackberry canes. There are many gall-producing insects in Tennessee, working on various oaks, briars, and weeds. Covers writer's experience in rearing gall-producing insects for the last five years. Shows how galls are produced by a stimulus which is deposited by insect in young growing part of tree or plant, which causes an abnormal growth, much like a cancer on human body. The purpose of the gall, however, is to prepare a place for rearing the young insect. (Published in "Country Life in America," September, 1916.)

November 27, 1914.

SOME PERSONAL REMINISCENCES OF THE EARLY HISTORY OF THE TELEPHONE.

BY BROWN AYRES, UNIVERSITY OF TENNESSEE.

(Abstract.)

Having undertaken some original investigations in telephony about the time of the invention of the instrument by Alexander Graham Bell, the author was led to form an acquaintance with Professor Bell at an early stage of his invention, and to have had some pleasing personal relations with him at that time. He was also, at the same time, a frequent visitor at the laboratory of Mr. Edison,

and was thereby put in a position to estimate exactly what contributions to the development of the telephone were made by him. The author published, in the Journal of the Franklin Institute for June, 1878, the first mathematical discussion of the theory of the telephone, with the results of some experiments made by him, which have since proven to be of great practical value to the telephonic practice.

November 27, 1914.

SOME MALIGNED BIRDS.

BY DIXON MERRITT.

(Abstract.)

Balance of nature, in which species whose primary influence is injurious become beneficial by holding other injurious species in check; how species whose primary influence is beneficial would become injurious if allowed to increase without check. Importance in balance of nature of hawks, owls, crows, grackles, and certain other species that man ordinarily seeks to destroy. Positive economic benefits conferred by these species.

November 27, 1914.

WHY POTTERIES SHOULD BE ESTABLISHED IN WEST TENNESSEE.

BY WILBUR A. NELSON.

(Abstract.)

Better domestic raw materials can be assembled cheaper in Tennessee than in probably any other section of the country. West Tennessee contains the best deposits of ball clays in America. Freight rates in the south, southeast, and certain parts of the southwest are much cheaper than from present pottery centers in East Liverpool, Ohio, and Trenton, N. J. Type of ware best suited for making in the South is sanitary ware and general tableware.

November 26, 1915.

AN IRRIGATION SLIDE FOR PROLONGED OBSERVATION OF LIVING AQUATICS

BY SAMUEL M. BAIN, UNIVERSITY OF TENNESSEE.

(Abstract.)

An ordinary culture slide, with the concavity placed toward one end, has a small trough scratched so as to reach the center of the slide. In this groove a capillary tube is cemented, reaching to the bottom of the concavity. Water placed in the latter, protected by a cover glass, will supply that lost by evaporation from beneath the cover glass adjoining. Illustrated by lantern.

November 26, 1915.

A SIMPLE DEVICE FOR AERATING AQUARIA.

BY SAMUEL M. BAIN, UNIVERSITY OF TENNESSEE.

(Abstract.)

An ordinary Tantalus cup of convenient form and size has a somewhat smaller jar inverted within it. From the latter a tube leads the air current into the top of a large-mouthed jar. From this jar the air is led into the several surrounding aquaria. Into the stopper of the distributing jar a tube is fixed, which dips a little below the surface of some paraffin oil at the bottom. On running a slow current of tap water into the Tantalus cup, the air is forced out of the inverted jar into the aquaria. When the siphon overflows, a current is set up in the opposite direction, but the intake of air occurs through the tube dipping into the paraffin oil. The device supplies an intermittent air current, the rapidity of which can be controlled by varying the water supply to the cup. Illustrated by lantern.

November 26, 1915.

PHOSPHATE ROCKS OF JOHNSON COUNTY, TENNESSEE.

BY OLAF P. JENKINS, STATE GEOLOGICAL SURVEY.

(Abstract.)

The recent discovery and primary development of phosphate rock in Johnson County has exposed some new and interesting scientific problems and may later prove to be of economic importance. A chemical and mineralogical study of the material found, in connection with the field work, shows that the phosphate rock in this region is formed usually as a secondary concentration in residual brecciated rocks which were originally limestone. The geological horizon for the phosphate is apparently the upper beds of the *Shady limestone* and the lower beds of the *Watauga shale* of Keith's nomenclature. (Published in "Resources of Tennessee," Vol. VI, No. 2.)

November 26, 1915.

RECENT RESULTS IN MATHEMATICAL ASTRONOMY.

BY H. E. BUCHANAN, UNIVERSITY OF TENNESSEE.

(Abstract.)

The purpose of this paper is to present in non-technical language the results attained in some recent papers on the Problem of Three Bodies. Only a part of these results are due to the author, but they are all closely connected. No mathematical formula is used, and it is hoped that the statement of the problem and the results obtained are made interesting to scientists in other lines of work.

November 26, 1915.

THE EVOLUTION OF MISSISSIPPI RIVER CRAFT AS INFLUENCED BY GEOGRAPHIC CONDITIONS.

BY CHAS. C. COLBY, GEORGE PEABODY COLLEGE FOR TEACHERS.

(Abstract.)

This paper deals with the geographic factors which brought about an evolution in the type of boats used in the successsive periods of

the development of navigation on the Mississippi River and its principal tributaries. The more important of such factors were the character of the river bed, the variations in the depth of water, the obstacles to navigation, together with the rapid spread of population and the utilization of new resources in the Mississippi Basin.

November 26, 1915.

THE ORDINATION OF SCIENCES IN EDUCATION.

BY R. I. RAYMOND, UNIVERSITY OF THE SOUTH.

(Abstract.)

An outline of the relation of scientific information to education in general, and a suggested optimum arrangement of the several sciences in the educational plan.

1. The relation of the sciences to education as a whole. Need of factual information as distinguished from the process of mind-exercise in studies.

2. The place of the sciences in educational evaluation with reference to the grade of educational institutions. Possibility of effective training under different conditions of school efficiency and advancement.

3. The order of the sciences in the scholastic scheme.

4. The *essentials* of each science in an ideal presentation, as distinguished from the commonly taught "available data and experimentation."

5. What may be expected from a broad scientific education as a full justification of its establishment in common schools.

November 26, 1915.

EXPLORATIONS OF THE MOUNDS AND CAVERNS OF TENNESSEE.

BY W. E. MYER.

(Abstract.)

An extensive Indian town at Castalian Springs, Tenn., was explored by Mr. Myer. This town covered about fifty acres and con-

sisted of five mounds, a line of embankment and a large stone grave cemetery.

One of the smaller mounds contained over one hundred stone grave burials and yielded many splendid specimens of aboriginal workmanship. Some of these are of great importance in throwing light on the Cumberland Valley Indians having come under the influence of the thought and traditions of the Aztecs. Many of the ornaments, while of local make, were strikingly Mexican in type.

The graves in this mound yielded many traces of curious and unique customs; such as the burial of two or more bodies in one coffin, the raking to one side of the bones of a former burial and placing a new body in coffin, the burial of fleshless bones in bundles; the burial of crania, unaccompanied by other bones, in small stone boxes; the burial of children with adults in such positions as to arouse suspicion that the child may have been placed in the grave alive.

Mr. Myer has explored many of the caverns and rock-shelters of the Cumberland Valley. Pictures of several of them are shown, and samples of rare burial mattings from these shelters are displayed.

He shows a picture of the great rock shelter at Lover's Leap, where the ashes and kitchen refuse, mingled with rock from overhead, reach a depth of thirty feet. This shelter is of great age. From its military position of great difficulty of attack, and because it faced the south and was sheltered from the north, east, and west winds, it was admirably adapted to the needs of savage man. It was doubtless inhabited by primitive man from the time he first reached the valley.

November 26, 1915.

CAUSE OF THE STYLOLITIC STRUCTURE IN THE TENNESSEE MARBLE.

BY C. H. GORDON, UNIVERSITY OF TENNESSEE.

(Abstract.)

This paper discusses the nature of the structure known as Stylolites, with special reference to its occurrence in the marbles of East Tennessee. The various theories proposed to explain this structure

are reviewed and attention called to the most probable explanation.
November 26, 1915.

NATURE AND ORIGIN OF THE HOLSTON MARBLE FORMATION IN EAST TENNESSEE.

BY C. H. GORDON, UNIVERSITY OF TENNESSEE.

(Abstract.)

In this paper evidence is presented to show that the materials making up this formation were accumulated in shallow water and that it corresponds in many respects to formations considered to be of reef origin. While the organic nature of the deposit is unquestionable, corals are rare. The remains of bryozoans and other organisms, however, are abundant, from which fact the conclusion is drawn that the reefs were of the nature of bryozoan reefs rather than coral reefs.
November 26, 1915.

WEST INDIAN HURRICANES; THEIR ORIGIN, MOVEMENT, AND EXTENT.

BY ROSCOE NUNN, U. S. WEATHER BUREAU.

(Abstract.)

The frequency and violence of the hurricanes that visited the Southern States in the summer of 1916 are mentioned, and their unusual features noted. Origin of the name "hurricane". Differing characteristics of the storms of middle latitudes and the hurricanes of the tropics. Characteristics of tornadoes distinguished from those of hurricanes. Development of knowledge concerning hurricanes. The several theories to account for the origin of storms. The convectional theory of the origin of hurricanes. Reference to the work of Prof. William Ferrel and "Ferrel's Law". Geographical and seasonal distribution of hurricanes. Paths of hurricanes and their rate of progress. Illustrated (by means of the reflecto-

scope) with weather maps and hurricane charts published by the Weather Bureau.

December 1, 1916.

THE *RAISON D'ETRE* OF THE TENNESSEE ACADEMY OF SCIENCE.

BY SAMUEL M. BARTON, UNIVERSITY OF THE SOUTH.

(Abstract.)

In this paper the author first gives a brief account of some of the State Academies of Science, calling attention to their purpose and the scope of their activities. He shows that the results of the work of these societies justified their existence. As to the Tennessee Academy of Science, while its growth has been slow, it has held its own. The author's contention is that this Academy has been and will continue to be beneficial to the scientists of the State and to the State itself, both directly and indirectly. It is a good thing for men in different branches of science to meet occasionally and hear papers even on departments of science of which they know nothing. There is a good here to be accomplished not possible in the exclusive meetings of special societies, though the latter are most important. The interchange of views of specialists in different subjects is most helpful. The resources of Tennessee are enormous, far greater than most Tennesseans are aware of. The Academy should become a power in helping to develop these resources. In the mind of the speaker there is a great future of usefulness for the Academy. To this end he urged the importance of quality rather than a large membership.

December 1, 1916.

THE CUMBERLAND PLATEAU AS A CROP-PRODUCING SECTION.

BY J. E. CONVERSE, TENNESSEE EXPERIMENT STATION.

(Abstract.)

From actual observation and experiment, the author names the crops that may be grown successfully, and shows that the Plateau

soil and climate are well adapted for the growth of the finest quality of vegetables, fruit, and small fruit. Parts of the region are especially adapted to the production of large yields of the finest quality of white potatoes. Buckwheat does well on the Plateau, and its value as a crop is emphasized. Corn and wheat are grown, and, with intelligent care, excellent yields are secured. Cattle graze on native pastures for six or eight months in the year.

May 4, 1917.

THE CLIMATE OF SEWANEE, TENNESSEE.

BY ROSCOE NUNN, U. S. WEATHER BUREAU.

(Abstract.)

Sewanee has a type of local, "mountain" climate that presents some interesting features. Its distinguishing characteristics are brought out by comparison (1) of the physiography, or local topography, of Sewanee, with that of other places in Tennessee, such as Erasmus, Rugby, Lookout Mountain, and Mountain City, and (2) a comparison of the climatic records for these places. The source and nature of the climatic data for Sewanee (which cover the last twenty-two years) are explained, and the climatic elements exhibited by these data are discussed, principally the temperature conditions.

May 4, 1917.

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